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CONTENTS.

An Asterisk (*) denotes an illustrated article.

EDITORIALS—

The Man at the Helm..... 225
The Advance in Petroleum..... 225
Official Darkness in New Orleans, La..... 226
More about Mr. Edison and His System..... 226
Petroleum Deposits in the Argentine Republic..... 226
Proceedings of Tenth Annual Meeting of the American Gas Light Association*..... 227
Electric Units..... 235
Electric Lights a Nuisance..... 235
The Estimation of Sulphureted Hydrogen in Gas by Direct Weight. 236
Gas Works and Chemical Industry..... 236
An Improved Gas Engine..... 237
The Efficiency of Washed Coal..... 237
The Connellsville Coke Industry..... 237

THE MAN AT THE HELM.

In the able address of the President of the American Gas Light Association at the recent meeting at Pittsburgh there were many points that will well repay a careful study. Some of these are merely hinted at while others are more broadly referred to. There is no question in the speaker's mind about many things which are considered debatable. Undoubtedly the experience of President Hickenlooper is a unique one; holding, as he does, the position of president and engineer of his company he becomes the manager of his company in a much broader sense than is usual in this country—hence he can speak of those delicate relations existing between the two branches of the business, viz., the sale and the manufacture, without prejudice; for, in his case, he is the man at the helm most emphatically.

But the point to which we would draw particular attention is the simple question—why are the relations between a gas company and the public, the authorities, the private consumers, such as they are represented to be, a mere drifting, shifting current, filled with constantly changing shoals and quicksands, through which the man at the helm must pilot his corporation in safety? What, in days gone past, has been the hidden cause for the existence of such conditions? There can be but one answer. The cause is to be found in the way in which "that delicate duty of shaping and defining the policy which shall govern and control the business affairs of the companies" has been performed, or, shall we say, neglected. To those who are familiar with the methods pursued by some boards of direction it may seem strange that some companies exist at all, while, in other cases, the do-nothing, spend-nothing policy is enough to secure the just contempt of any community. The fact can be demonstrated that where the business of a gas company is carried on in a fair, business-like manner there is little trouble between the management and the community. The man at the helm has an easy time. If the general public are to a certain reasonable extent treated with confidence they will not be unreasonable in the making of contracts. Of course, there are "strikers" who "agitate" perpetually and professionally simply for personal gain; but they should be met simply by exposure, and public sentiment will condemn them.

There is no one thing, in our opinion, that will tend more strongly than anything else to stop the howl against the "enormous profits" of gas companies than the publication of the accounts, from which any business man can see that he is paying only a reasonable profit on what he uses.

In England every company is required to do this by law in a prescribed form, and the result is that anyone can know exactly the condition of each company in the country. Of course when the reasonable dividend is reached a reduction in price must follow; and there is no reason why the price of gas should not change as that of any other commodity. It is because the business policy of many companies in times gone by has not been based on business principles that the man at the helm has had to steer his craft through ways that were unlighted and channels that were crooked. The everlasting policy of mystery has been too often the rule, supported by the practical application of the theory of "pocketing what dividends we can while we have a chance," and herein may be found some of the causes of want of harmony between consumer and supplier.

But, thanks to the wisdom of better councils, these things are passing away; and perhaps nothing has done more to contribute to this result than the formation of the different gas associations throughout the land. The result of their meetings has been of immense value to the consumer and to the stockholder; and we doubt not that in time their influence for good, and for the establishing of the business policy upon simply a business basis, will be such that the man at the helm will have plain sailing and easy courses. Let every company do as any merchant does who desires to advance his business. Advertise; make known the true merits of his commodities—in fact, be wide-awake, and "go for" business, not wait for it to come to him. Then the man at the helm of such a company will find that not only the "bow oar," but every other man in the boat will have to do his best to meet the demands which will accompany the incoming tide of safe prosperity.

THE ADVANCE IN PETROLEUM.

A great and surprising revolution has taken place in the state of the market for crude petroleum, and the prospect for a still more marked rise appears at the present time of writing to be almost a certainty. From reliable sources we learn that the daily consumption is at least equal to the daily production,

and shrewd operators incline to the belief that the time is not far distant when the surplus stocks on hand will require to be drawn upon to meet the requirements of the refining trade.

When the first reports concerning the developments in the Cherry Grove district were verified, we had the rather astonishing spectacle of oil at fifty cents a barrel. On Friday, November 10th, at Bradford, Pa., petroleum was quoted as high as $1.36¼, and closed, on the same date, at $1.24¾ bid. With a diminishing production and largely increasing consumption it is quite safe to predict very much higher rates than those at present ruling.

Official Darkness in New Orleans, La.

On the night of November 8th the supply of gas was cut off from the public buildings and lamps in the city of New Orleans, La. The New Orleans Gas Light Company having been unable to obtain from the authorities payment of its bills for public lighting for several months back, and having received no assurance that such bills would ever be paid, were obliged to resort to a stoppage of the supply. The result being that the city was left in darkness, and much confusion resulted. The cutting-off of the supply soon brought the authorities to terms, and arrangements were made which speedily ended the difficulty, and the gas was again turned on.

The New Orleans *Daily Picayune*, of November 9th, contains the following description of the state of things as they existed on the evening before—

"Last night the different police stations throughout the city were in perfect darkness, the gas company having refused to supply the city any longer with light—the city government being in a state of financial embarassment and was unable to pay the company for the lighting of the streets and public buildings throughout the city. The telegraph operator at the Central Police Station resembled a person at a wake, being surrounded by candles, stuck on his table, while the clerk and turnkey of the station down stairs appeared to be in a tomb, not a ray of light being visible in their quarters. The prisoners were very quiet under the circumstances, seeming to lose all tendency to loquaciousness in the darkness.

"The Third Precinct Station was in a similar condition, the glimmer of one single candle, purchased by the clerk, was seen. About 10 o'clock in the night a prisoner was brought in, and it was after considerable trouble that he could be placed in a cell on account or the extreme darkness.

"The Harbor Police were brought out on the Levee to roll call and answered to their names by the electric light.

"During the day Chief Boylan was informed that the gas would be cut off at night, and so informed his subordinates. The clerks and police think it very hard that they have to work so many months without pay and then buy their own candles in the bargain."

More about Mr. Edison and His System.

It will be remembered that our issue of October 16th contained some statements made by Mr. Edison to the reporters of two of the daily journals of New York city. It will also be recollected that Mr. Edison, and his superintendent, stated quite positively that nothing was going wrong in the working of his scheme for incandescent lighting—in fact, that "everything was lovely." That the hue was not "all rosy" would seem to be proven by the following interview which he had with a reporter of the New York *Daily World*, on Nov. 3d, and which is here reproduced.

EDISON ON HIS LIGHT.

The Edison Electric Light Company, which has secured the right to light all the buildings of the city with electricity, subject to the option of the owners or occupants of the buildings, has been for months laying wires throughout the district bounded by Spruce, Nassau and Wall streets and the East River. The city has been divided into thirty districts, and the one just mentioned is the first to be developed and is intended to demonstrate the practical workings of Mr. Edison's district system. The station is in Pearl street near Fulton, and there are already six immense dynamo machines, each run by a 200-horse power engine, completed and ready for operation. Each dynamo is capable of furnishing sufficient electricity to run 1,400 lights, and as, when the whole district is completed, there will be over 14,000 lights to furnish, it will be necessary to have six more similar machines to operate the entire district. The six dynamos already completed and set up were ready for use four or five weeks ago, but when they came to be tested defects were found to exist in the machinery which were at once recognized as serious and which it has taken Mr. Edison all that time to overcome. Each engine and dynamo are on one bedplate, and form one machine. The idea was to turn all the electricity generated by the six machines into one set of mains. When the experiment was tried, however, the result was not what had been expected. The difficulty, as explained to a *World* reporter by Mr. Edison, may be summed up as follows:

"I found on trying the experiment," said Mr. Edison, "that the trouble was that when the electric current from two dynamos was united it was impossible to make them work smoothly, for the reason that if one engine ran faster than the other the fast engine would take all the load off the slow one, and the slow engine would be run merely as an electro-motor. The result of the first experiment was such as to astonish the engineers and every one who witnessed it, and came near proving serious. When the current from the second dynamo was turned on, first one engine and then the other would go like lightning, and first one and then the other was converted into a motor. One of the engineers, witnessing the effect, shut off steam, and still his engine was running just as rapidly as before. He came running towards me as white as a sheet, exclaiming: 'My God, Mr. Edison, what is the matter? I have shut off the steam, and yet my engine is running at lightning speed, and I can't stop it!' In addition to the 200-horse power engines running at a high rate of speed, there were also attached to each a four-ton bobbin, which in effect increased the power equal to about 1000-horse. The next thing that happened was the melting in a second of six or eight pounds of copper which was thrown off in a sort of vapor, filling the room and nearly blinding every one present. Everybody groped their way to the windows, half frightened to death. If the whole six machines had been in operation at the time I do not know what would have happened. I suppose everybody would have jumped out of the windows. I tell you it was a pretty serious piece of business, and I saw at once that I had a pretty difficult job before me to overcome it. But I saw what the trouble was and what would have to be done to remedy it.

"The problem to be solved was to invent some plan by which all the engines could be made to run at the same speed, so as to make them practically one engine. And that is just what has occasioned the delay. As many of our customers had dispensed entirely with gas, and were relying upon us for light, it was necessary for us to furnish them, and hence we were forced to manufacture some electricity. I at once applied myself to the task of perfecting an apparatus whereby all the automatic regulators of the several engines could be connected, and this plan was soon perfected. But it has taken a month to construct and perfect the apparatus. It is now completed and in perfect order and it works to perfection. We are turning on lights every day and I can safely assert that all obstacles have been overcome and that the success of the district system has been placed beyond doubt or question. The district in question will, when the entire plant is completed, contain about 19 miles of underground wires, of which about seven miles are already laid and connected.

"The entire feasibility of running electricity through wires laid underground had also been thoroughly demonstrated, and I have now no fears whatever of the perfect working success of the scheme. I have also perfected a meter for measuring the amount of electricity used in a given time, which is absolutely perfect and certain, because not mechanical, and therefore not liable to get out of order. Furthermore, the production and sale of electricity for lighting purposes will in no way come in competition with gas, any more than gas does with kerosene, because it has an actual commercial value above gas, which will take it out of the line of competition and elevate it to a plane of its own. We measure electricity, for instance, on the basis of a ten-candle power of illumination, and we charge at the rate of one and one-sixteenth of a cent an hour for a ten-candle light. It makes no difference whether a consumer burns ten candles' worth an hour or one hundred, he is charged accordingly. Electricity is worth, as a commercial product, one-third more than gas, and therefore people will use it and pay one-third more for it than they will for gas. Of course, the system is not yet by any means perfect, but I am constantly working at it, and in three months' time I will have it down pretty fine, as the saying is. I do not consider the lighting of the streets as of any importance whatever, and have never had any desire to compete in that line of the business. I have been holding back until I have got my system perfect, and now I am prepared to go ahead. In the first place people said that the wires could not be laid underground. I have fully demonstrated that they can. The lighting of the streets does not represent one-fifth of the future possibilities of the business that I have been striving for, but it is the miles and miles of houses with the $5, $6, and $8 per month from the thousands of customers that I am after. The result of the experiment in the district now being developed will tell the story. If it is such as to satisfy the capitalists that it is a success, which I have no doubt it will be, other districts will be worked as fast as the plants can be laid and the stations established. I fully expect in time to light the whole city of New York by means of electricity."

Petroleum Deposits in the Argentine Republic.

In the upper provinces of the Argentine Republic there have lately been discovered petroleum deposits, apparently of great richness and extent, and it is believed that the eastern slopes of the sierras of the Andes are underlaid in many places with this mineral oil.

[Official Report—Continued from page 211.]

Tenth Annual Meeting of the American Gas Light Association.

Held at the Monongahela House, Pittsburgh, Pa.,
October 18, 19, and 20, 1882.

Afternoon Session.—Oct. 18.

The Association resumed the discussion on the paper presented by Mr. Pratt.

Mr. Pratt—I presume you have heard enough from me to-day, and I do not desire to take up any more time than is necessary; but I wish to say one or two things by way of explanation. I did not mean to be understood as saying that we have reached the limit of reduction in the price of gas. So far as our price is concerned, I know it is too high. We have not availed ourselves of all the improvements we might, and consequently our gas has cost us more than it ought. We expect to make gas cheaper hereafter. The other point that I desire to refer to is the importance of letting the people know just what we are doing. We let them know that we make 8 per cent. per annum dividends, and allow a reasonable sum for depreciation and repairs, and they have been satisfied with our statement. Those are all the points that I intend to raise with regard to our company; but I want to say in this connection that $3 per 1,000 for gas there is quite as cheap as $1 per 1,000 in Pittsburgh. Our coal costs us three times as much; our consumption is smaller; and we run over a very large territory. Therefore our price is not high as compared with that of other companies. The main point of my paper is that I believe it will be incumbent upon gas companies hereafter to keep themselves closely connected with the people—to let the people know what they are doing, and to satisfy the people that they are not making exorbitant sums of money. The great cry to-day is against monopolies. A cry has been raised against the railroad companies because of their watered stock. Companies cannot pay dividends upon fifty or one hundred millions of watered stock. The public will not consent to paying large dividends to gas companies upon watered stock. The public must know that the gas companies are receiving only fair and liberal dividends. We hear it said that a fair and ample dividend is 10 per cent. I claim that the public will not stand that in the future. They will allow a fair, ample, and reasonable dividend, but when it comes to that figure they will say that in an interest so near to them as the gas interest, they will not permit the companies to earn such a large amount of money. With all respect to the gentlemen who have spoken, I do not think that the only point which I raised has been met—that is that the gas interest has to be near the people; that the people must know what the companies are doing; and when they do know it, they will be satisfied.

Mr. Price—I will ask you whether the people would be better satisfied with gas at $3 per 1,000 feet, and paying the company 8 per cent. dividend, or with gas at $2 per 1,000 feet, and paying the company 12 per cent.

Mr. Pratt—That is rather a difficult question to answer. I think if a company sells gas at $2, and earns 12 per cent. dividends at that price, the public will be apt to demand a decrease. They will say to the company, "You are making too much money." But if a small company, in a small town, is making only 8 per cent., I do not think the public will object.

The President—The point which Mr. Price raises is whether, through mismanagement of the company or otherwise, a company which is able to pay only 8 per cent. dividends, while charging $3 for gas, would be any nearer the people than the company which was charging the public $2, and, by reason of better management, or improved works, was able to pay a 12 per cent. dividend. In other words, whether the standard of nearness to the people is to be determined by what you are to be permitted to charge for gas, or what you are to be permitted to earn.

Mr. Price—The President has stated the point of my inquiry exactly.

Mr. Pratt—I adhere to my proposition that the public will not consent to pay such enormous dividends as 12 per cent., with such a large amount of surplus. They will demand all over a reasonable dividend and surplus—that it shall go to them in a reduction of the price charged for gas.

The President—If that is true, wherein is the incentive to a more economical production? If consumers are satisfied to pay $3, with the knowledge that the company is getting only 8 per cent., the company will be apt to continue without making improvements.

Mr. Pratt—A constant clamor is being raised by the people for a lower price of gas, and you must meet that clamor and put the price of gas down. I think the true criterion of a successful gas company is that the company shall furnish gas at the lowest price, with a proper, reasonable, and liberal compensation to the stockholders upon the amount of capital invested.

The President—How do you reconcile your two propositions—one, that the public is to be satisfied with the dividends earned, and the other, that it must be satisfied with the low price of gas. You seem to apply two different gauges to the public.

Mr. Pratt—I cannot compare the two and state each relatively; but I know that no company that pays a 12 per cent. dividend in the future, at the prices which money is likely to bring in this country, and keeps a large surplus in reserve, will be likely to satisfy the public.

Mr. McElroy—Mr. Pratt states that his company is a small one, and that he has not made use of all the improvements in the manufacture of gas, and consequently the price of the gas is higher than it ought to be. Had he made use of all the improvements in the manufacture of gas, would it not have been better to have charged the public a litttle less, and made more money for the company? It would certainly have been better for the consumers. His gas costs the public $3, and pays the company 8 per cent. If he had availed himself of all the improvements in the manufacture of gas, and then been able to sell gas cheaper, would not the community be so much the better off?

Mr. Pratt—As I said before, I do not present my own company as a model; but my general theory is that, in the future, the public will have to know what the gas companies are making; they must be satisfied that they are making reasonable and proper dividends, and are furnishing gas at the lowest price consistent with reasonable dividends.

Mr. Richardson—Following that line, I will give the Association the result of our experience with our small works in North Adams, Mass. Previous to 1878 the price of gas was $3; in 1880 there was a 10 per cent. discount given, making the gas $2.70. In that year we manufactured a little less than six millions. During 1881 we reduced to $2.50, and that year made nearly eight million. Last year we made a special price of $2.25. Up to this time our sales will exceed twelve millions a year. During this present month we shall make, at those figures, more gas than during the month of December last year. Ours are small works, but the results show the disposition of the people to burn gas more freely at lower prices.

Mr. Helme—Mr. Pratt will not, by letting consumers know what dividends his company is paying, free himself from the criticism which he thinks will be made. He may publish to the public what money the company is making; but the people are becoming so well educated as to the manufacture of gas, and the intercourse between people in different places is so great, that they will begin to compare notes with each other; and it may be that in a town of the same size as Jamaica Plain, but a few miles distant, they have the means of making gas a little cheaper, and sell it for less; and then they will begin to ask such questions as, "Why do you charge us $3 for gas, when our neighbors are paying only $2.50 or $2.75?" Then Mr. Pratt will have explain why it is that, while receiving $3 per 1,000, he is able to pay only per cent. dividends. He will have to answer these questions by saying either that he cannot manage the business so well as his neighbors, or that he wants to make more money than the neighboring company is satisfied to make.

Mr. Pratt—I admit the truth of the assertion that the public have the right to demand the lowest price. I do not bring my company into comparison with others in that respect. All the gas companies in my neighborhood charge the same price as we do. Some of the neighboring companies have constructed new works, with all the latest improvements, but they charge the same for gas that we do. We think that with our improvements we can furnish it lower, and it is our object to do so. I agree that the gas should be made about as cheaply at one place as at another in the same locality, and with that in view, all the improvements which are in use should be adopted.

Mr. Helme—I think Mr. Pratt is pursuing the same course which many of us have been following for a great while, although we have not said much about it. That is just exactly what we are doing and have been doing. We tried first to make our dividends, and then to save a little to meet our extensions; and then if we had anything left we gave our customers the benefit of it. That course has been pursued by every company in which I am interested. The one in which I am principally interested formerly sold gas at $5 per 1,000; now we are selling it at from $1.80 to $2.40. That is in the South, where we do not expect to get things cheap; but I am surprised to hear that around Boston $3 is charged.

Mr. Sherman—There is a gentleman present who is somewhat conversant with the internal affairs of the New York companies. He informs me that since they raised the price from $1.50 to $2.25 some of them have increased 40 per cent. in consumption.

The President—I have no doubt that, because of the increasing prosperity of the country, every gas company in the United States is sending out from 10 to 20 per cent. more gas this year than they did last. That includes companies which have made no change in price as well as those which have made reductions. We should hear also from the companies which have made no reductions.

Mr. Greenough—We have made no change in price for two years. Last year we made an increase of about 14 per cent.; but our increase this year is small.

Mr. Rollins—We made no change in price last year, yet in the month of September our increase was more than 10 per cent.

Mr. Pearson—It takes a little time for the people to understannd the value of a reduction in price. It may be a full year before they understand that there is a benefit to be derived from it. Our company reduced the price two years ago. The consumers who were using gas at a reduced price, and had received the benefit of it for a year, could then tell their neighbors, and their neighbors could use more of it. That thing is not always fully understood at the end of the year. So far as our company is concerned, we have not reduced the price this year, and our increase is quite as great, relatively, as it was before. The reduction which was made two years ago began to tell a year ago more perceptibly than it did during the year in which the reduction was made.

The President—Was that increase due to the reduction, or is it due to the increasing prosperity of the country?

Mr. Pearson—In our case it was due to both.

Mr. Sherman—I will state a little of our experience, which may illustrate this point. In 1861, at the breaking out of the war, when there was a great cry for economy, I was running some small works; and to satisfy the clamor for cheaper gas (this clamor came mostly from the GAS LIGHT JOURNAL) we put the price down from $4 to $3. The result was that we sold less gas at $3 than we had been selling at $4. Of course, in a very short time afterwards we raised the price from $3 to $4.50, and owing to the increased prosperity of our customers our consumption was largely increased, showing that the price does not always influence the consumption to the extent which is generally attributed to it. The fact is that the people burn it when they can afford to; and we cannot make any price which can compete with kerosene. So long as four gallons of kerosene will give a light equal to that of 1,000 feet of gas, we can practice no economy which will successfully compete with it.

Mr. Forstall—In 1872 the price of gas in New Orleans was $4 per 1,000 feet, and we sold 269,000,000 feet. In 1881 it was $2, per 1,000, and we sold 250,000,000. So that the reduction in price of 50 per cent. did not give us an increase of consumption sufficient to make up for the loss during the time of the depreciation between 1872 and 1881.

Mr. C. H. Nettleton—The company with which I am connected commenced to sell gas in 1872, and for several years kept the price at from $3.75 to $4 per thousand feet, and the consumption not only remained small but almost stationary. After running in this way for three or four years the price was reduced by a small amount and immediately the consumption increased, so that the profits were a little larger than they had been at the higher price. This reduction was followed by others; and each time the result was the same—an increased consumption and a somewhat larger balance on the right side.

At the present time, with the price a trifle under $2 per thousand, the consumption is over one and one-half millions per mile of pipe, and the profits afford a fair return on the capital invested. I know that a part of the increased consumption is due to more prosperous times, and to an increased population; but I cannot help believing that were the price to-day above $2 per thousand, the consumption would be so much less that the profits would be smaller than they now are.

Mr. Price—This seems to me to be a discussion of considerable importance, and I should be very sorry to have the debate close and leave an erroneous impression with regard to the truth in controversy here. A few moments ago I began to suspect that if you would call for testimony you might perhaps raise witnesses enough to be able to prove that the true way to increase the consumption of gas would be to increase the price. The tendency of all the testimony seemed to be in that direction.

The President—We have had that proven, in one case at least.

Mr. Price—That has been proven in another case, unless the facts on the other side can be brought out.

I am unable to see why the business of making and selling gas is to be considered as differing essentially from the business of manufacturing and selling any other article of general consumption. I do not see any reason why the same business laws should not control in the manufacture and sale of gas as in the manufacture and sale of cotton cloth, or any other article in general demand. I think we make a mistake if we lose sight of the fact that we are simply manufacturers and retailers, and I think this fact has been too often lost sight of. Some years ago the impression among gas manufacturers seemed to be that the price at which gas was sold did not very greatly affect the quantity sold; that it would not come into general use; that the well-to-do class would use it, even at a higher price—in short, that the true way for a gas company to make money was by the sale of a moderate quantity of gas at a high price. I do not mean to misrepresent, but it has seemed to me that a sentiment, much as I have stated it, did prevail and control the action of gas managers.

Now, I am one of those who hold to precisely the opposite doctrine, to-wit, that the true way for a gas company to make money is to sell a large quantity at a small profit per thousand feet. I believe gas may be produced and distributed at so low a cost that it may be sold cheap, and thus its use may be widely extended. It may be sold at a price which will bring it within the means of a very large class of people who are now compelled to use petroleum because it is cheap and, in many towns, gas is dear. It should light the cottage of the laborer, and not be confined to the houses of his employers.

While I cannot agree to all that our friend, Mr. Pratt, has said, I think there is much that is true in his paper. His main point, I understand to be, that the gas business shall be so conducted as to secure the moral support of the community to the management of the company. This, he thinks, can be done by satisfying the public that only a moderate profit is made upon the capital invested. Of course, it will be quite impossible to satisfy all, and as I take it the first point to be gained is the approval of the better citizens of the community—those whose good opinion is valuable and sustaining. It is clear that Mr. Pratt's neighbors are satisfied to pay $3 per thousand feet for gas because they know that he is not making a large profit. They probably do not go into the question whether he is using the best apparatus to produce the best gas at the cheapest rate. I presume his people are not particular—the town being composed chiefly of gentlemen who do business in the city of Boston, who are for the most part wealthy, and are not anxious as to the price they pay for gas, so long as they have good light in their houses. Is not that so, Mr. Pratt?

Mr. Pratt—That is somewhat so. Our people are not disposed to grumble much.

Mr. Price—In that respect your consumers are quite different from the people of cities where a great many would be glad to take gas, if it were sold at a moderate price, but who cannot take it if sold at a high price. Our experience has been this—when we were authorized by the city of Cleveland to lay pipes in the streets (there is no monopoly with us) we were authorized to sell gas at $3 per thousand feet. It was sold for that at first, commencing in 1849. Of course, people who had adequate means took it at that price. Kerosene oil had not then been discovered. In the course of time a company was started upon the west side of the Cuyahoga river. The company which I at present represent thereupon reduced the price of gas. At first we reduced the price, on the side of the river where the opposition company was located, to $1.50, but kept it at $2.50 on our own side of the river. I mention this to show the bad effect of such a course. As soon as we did that we began to lose consumers on the other side of the river. One customer would pay the company on the other side of the river $2.50 rather than take the gas from us at $1.50. The public said to our company, "If you can afford to sell on the other side at $1.50, you can afford to sell on this side at the same price." That course raised up an opposition which threatened to bring the other company upon our side of the river. I thought the position which had been taken by the company was an absurd one, and our Board of Directors became convinced that it was so; and in a little while we changed our plan, and treated both sides of the river alike. In fact, we sold our pipes and good will on the other side of the river to the other company, and both concerns commenced selling at $2.50. After a few years we reduced the price to $2. The reduction had a fine effect upon our business, and greatly increased our consumption. After running on a while at that rate we reduced to $1.80. This still further increased the consumption. A great many people who had been burning coal oil commenced taking gas, because they could afford to burn it. When such people commenced to burn gas the effect was very apparent in our increased sales. I have for some years been an advocate of the policy of selling a large amount of gas at a moderate profit, and believe that it is the surest way of making money. Two years ago we reduced the price to $1.65, and the effect of that reduction was very marked indeed. In going to my home in the evening I pass by a cluster of business houses, which, at one time, were nearly all using coal oil for illumination, and now they nearly all use gas, not because of our sending men among them to advocate it, not through any agency of ours, except the simple fact that we have reduced the gas to such a price that they feel that they can afford to buy and use it; and they do buy and use it; and our consumption has increased very rapidly under the influence, as I believe, of low prices. Of course, I am not oblivious to the fact that that increase has been assisted very much by the great prosperity of the times. We must not imagine that either of these causes is alone to be credited with the result. I have no doubt that the increase in consumption is largely due to the better times, to the better business, and to the better wages that people are getting, and, consequently, to the better ability to pay for the greater safety and convenience which gas affords as compared with oil. They treat gas as they treat everything else. The people generally use more tea and more coffee, they dress better, they drive better horses, they ride in better carriages, they build better houses, and, of course, they burn more gas. In Cleveland I think the introduction of the electric light has helped us. We believe that the arc light

has been a decided help, as introducing an inclination and desire on the part of the people to have better lighted streets. Not long ago the people of Cleveland, through the agency of one of the public officers, discovered that they were paying four or five times as much for the electric light on Euclid avenue as they had been paying us for gas to light the same thoroughfare. What was the reply of a leading daily paper of the city of Cleveland?

"What of it? The city of Cleveland, with 200,000 people, ought to be better lighted; and we can afford to pay for it!" If they can afford to pay for it we will demonstrate that gas will give a better light than electricity whenever the people will pay us a fair price for lighting the streets with gas. I wish to call your attention to a very conspicuous instance which happened in New England, and with which Mr. Greenough is undoubtedly familiar. Some years ago an attack was made upon the gas company of the city of Lowell, and an attempt was made to introduce an opposition gas company. How was that attack successfully repelled? It was done just in this way: The Lowell Gas Company were able to show to the people of the city of Lowell that from the beginning their intention had been to put the price for gas as low as possible, and pay the stockholders 10 per cent. upon their investment. They were able to prove, by some of the best men of the city of Lowell, who had been directors in the company, that such had been their policy from the beginning; and that from time to time they had reduced the price of gas, and were contemplating another reduction as soon as they could afford to make it, and keep the dividends at 10 per cent. The result was that the Board of Aldermen voted, by a large majority, not to allow the newcomers to enter the field. They said, "This company is doing well by us, and will continue to do well by us; and we had better stick by the old company, rather than take in a stranger who makes large promises which may very likely be broken." I think there can be no doubt that this result was largely due to the fact that the company had been willing to sell their gas at a moderate price, and has been contented with moderate dividends. On the question of dividends, I beg leave to differ from my friend Pratt. I do not think that 8 per cent. is a satisfactorry dividend upon money in an extra-hazardous business.

Mr. Pratt—I do not say that it is. I said that *we* were satisfied with it.

Mr. Price—You rich men can afford to be satisfied with it. I think that men agree, in this country as in Europe, that capital which is invested in extra-hazardous business, like that of gas making, ought to pay more than 8 per cent. The British Parliament, which used to be considered a conservative body, was willing, in 1862, when it divided up the city of London into districts, that the gas companies should make 10 per cent. profit, and declared that they would protect the companies in making that profit. That was in a country where 4 per cent. has long been considered a fair rate of interest, but where money is often loaned at less. In this country interest has been exceedingly low for the last few years, in consequence of the enormous amount of paper money; but this state of the money market is not likely to continue. I have no doubt that interest will gradually go up, until it reaches and maintains a higher standard in this country than it does in England. But in England, where money scarcely ever goes above 4 per cent., the popular sense of justice accords to a gas company the right to earn 10 per cent. upon its capital. Why? Because it is a hazardous business. People who put money into it cannot always take it out again when they wish. I do not think the best public sentiment of any community in this country would ask us to be contented with less than 10 per cent. Our company proposes to divide no more than 10 per cent., and to keep the price at such a figure as will enable us to do that, and at the same time to keep our works in good repair; and I believe that the community will justify us in doing that. We have tried in good faith to satisfy the people of Cleveland that we were endeavoring to do the fair thing by them, by bringing the gas down to a moderate price, and we intend to bring it still lower. I do not desire to be satisfied with less dividends, but I wish to make the gas good, and to make it so cheap, and to make so much more of it, that we can afford to sell it at $1.50, and make a 10 per cent. dividend at that rate. We are now selling at $1.65 to the general public, and at $1.25 to the city for the public lamps. I have talked longer than I intended, but I felt that this discussion ought not to drift to a conclusion and leave it to be inferred that perhaps it would be a good thing to raise the price. I think that the true policy of a gas company is to deal liberally and fairly with the public. How to do this is sometimes a difficult and complex question. In one community $3 is as cheap as $1.50 in another place. Perhaps the mass of the people are not very good judges as to this particular subject. The main point is to satisfy the intelligent public that you are selling gas as low as you can afford to.

Mr. Pratt—That is all that we do.

Mr. Price—You must sell the gas as low as you can, and satisfy the public that you are not making excessive profits. If you do this I think the public will be satisfied to take your gas, use it liberally, and pay you freely.

The President—The next paper will be read by Mr. Fogarty, on "A New Process of Making Water Gas."

Mr. Fogarty then read the following paper:

ON A NEW PROCESS OF MAKING WATER GAS.

We are all aware that in every manufacturing process there is more or less waste of the raw material; and it is the province of the student in his library, the scientific chemist in his laboratory, the cultivator upon his farm, the botanical and geographical explorer in his travels and explorations, and the manufacturer in his workshop, to lend his aid in producing therefrom valuable products, and to add to the general wealth by converting into a commodity, useful in the arts or in the economy of daily life, a hitherto waste and undeveloped product.

Each and all of us may thus contribute more or less to the general good of mankind. Everyone can contribute his quota to the general stock of information—can point out or suggest some pathway to useful discovery—some unperceived product seemingly fitted for a particular purpose, or direct attention to a particular staple which has not been so generally utilized as it might have been. Nature has yet in her storehouse many materials awaiting the discovery of man, fitted for the rapid advance of civilization and our domestic comforts. Each one, in his own range of observation, may add to the general stock of improvement, and discover something new, calculated to sustain and support his race, or to benefit his particular business or profession, and thereby contribute to the progress of the age.

In bringing to your notice, as I am about to do, a process of manufacturing water gas which, without egotism, I may claim to be a startling innovation upon established ideas and usages, I only ask for a calm consideration of the facts which I shall lay before you, asking you to prejudge or condemn nothing until you shall have mastered the substance of what I have to say; reminding you that what I am about to propose is not a whit more startling or extraordinary than the artificial production of butter, of sugar, or of the countless products of coal tar, and saying to you, in the words of Mr. Samuel Clegg, Jr., "He is a bold man who at the present day condemns a new thing without very deliberate consideration, and he is an imprudent one if he accepts for truth everything that is advanced in favor of a new thing without the same precaution."

I am fully aware that, in introducing to your notice a new process of making water gas, I may expect to be met with the prejudice with which every new departure from old established customs and usages is sure to be regarded.

If experience has shown that even in ordinary manufacturing processes, and in the usages and common avocations of daily life, a wide departure from established practices and precedents is justly regarded with disfavor and suspicion, and if it is preeminently reasonable and just that this should be so, I must expect that the attempt to introduce a startling innovation upon the present approved methods of making water gas will be received with the most extreme caution; for, independently of the great expense which a radical change in the process of manufacture necessarily entails, the risk of failure in the supply of gas, involving as it does such serious consequences to an entire community, is paramount to every other consideration, and justly renders the gas engineer distrustful of change and conservative in his ideas.

However conservative the gas engineer may be, and however distrustful of change, he cannot shut his eyes to the fact that the great want of the present time is cheap gas. The cry which is unceasingly heard upon both sides of the Atlantic is a loud and constantly increasing demand for cheap gas—for increased economy in construction, in manufacture, in distribution, and in consumption.

During the past few years—and especially since the electric craze, as it may well be called, has taken possession of men's minds and purses—the attention of the gas community has been earnestly directed to and fixed upon the absolute necessity of increased economy in the manufacture, supply, and consumption of their staple. Mr. W. Mackenzie, of Dumferline, said, at the meeting of the the North British Association of Gas Managers in July last: "It is abundantly evident that cheaper gas must be made and supplied, and to accomplish this our energies must be at once directed. Economy, then, must be the order of the day; and I am persuaded we shall not be found lacking in desire to inquire into and take advantage of such new and improved methods as may be devised and submitted to us for this end."

In addition to this, there is among the people generally a growing appreciation of the great value, cleanliness and economy of gas as a source of domestic heat, it being generally acknowledged that the only obstacle to its general adoption for cooking and heating is the high price at which it is sold. Any process, therefore, which promises such a marked reduction in the cost of gas as will enable it to be supplied to the consumer at a greatly reduced price, must have an interest for the gas engineer.

Although the past few years have been productive of marked economies as respects fuel, labor, and yield of gas, as well as in the several appliances for using it, whether for the purposes of light or heat, there is among the gas fraternity a strong and growing sentiment that, so far at least as regards increased economy in the cost of manufacture, the most promising field for

inquiry and experiment is the increase and profitable utilization of the residuals produced in the process.

Indeed, to so great an extent has the feeling that the residual products of the gas manufacture will in the near future more than repay the entire cost of production taken hold of the minds of the gas world, that we hear it prophesied almost simultaneously upon both sides of the Atlantic that the day is not far distant when gas will be the residual product and the business of making and distributing it will be tributary to and dependent upon other manufactures.

We find in the London *Journal of Gas Lighting*, of November 30, 1880, a paper read by Mr. G. E. Davis, before the Manchester Scientific and Philosophical Society, in which he asked, "What would happen to the vast industry connected with the manufacture of gas if the electric light took the place of gas?" And the answer he gave was, "Simply nothing. There would spring up, near the coal pit banks, distillers of coal merely—manufacturers who would distill coal at a low temperature in order to produce tar, and they would call the gas a bye-product."

Again, we find that in the inaugural address of Mr. Charles Hunt, delivered before the British Association of Gas Managers, as reported in the *Journal of Gas Lighting* of June 14, 1881, he makes use of these remarkable expressions: "Above all, the production of ammonia is in the highest degree worthy of investigation, not alone on account of its rising value as an article of commerce, but also because of the hopes that are very properly based upon its known adaptability as a most facile purifying agent. It is not by any means certain that the combination within the retort of the two elements of which ammonia is composed is beyond our control, recent experiments tending to show that this is accelerated by high heat, or, at all events, that by far the largest portion of the ammonia is produced toward the end of the process of distillation."

And again, we find reported in the *Journal of Gas Lighting* of September 13, 1881, a paper by Mr. G. Valentine upon "Two New Processes of Gas Purification, Based upon the Direct Utilization of its Impurities in the Production of Commercial Salts," from which I extract the following: "We may say, then, that in time the scale of gas manufacture will be revesed, coal will be distilled for the value of its present bye-products, and gas will be the bye-product. Experiments, then, are wanted in the way of research. Take, for instance, the cause of the formation of ammonia in the distillation of coal. What quantity, if any, is formed from the nitrogen of the air? If any, the quantity could be increased to any extent by taking into account the temperature and nascent state of nitrogen and hydrogen in the presence of red-hot carbon. Gas works will then be more appropriately called chemical works."

And still again, we find it reported in the *Journal of Gas Lighting* of August 8, 1882, that at the last meeting of the North British Association of Gas Managers, Mr. Young, of Clippens, whom you all know at least by reputation, read a most remarkable paper, in which he speaks of new works which he is erecting, and in which the following suggestive passage occurs: "If we are successful in obtaining 1 cwt. (112 lbs.) of ammonia from each ton of coal carbonized in our works, which I have no doubt will be accomplished, and at the same time produce some 50,000 cubic feet of powerfully heating water gas, I am satisfied that the gas manufacturing industry would be placed upon a sounder basis than ever. Coal will in all probability be the great source of power for ages to come. Electricity may and most likely will be the mode of motion found most effective in eliminating the energy of the coal to produce the results which we desire; but, so far as we can see at present, the power stored in the coal can be most economically converted into electrical energy by gasifying the coal and using the gas in a gas machine, more particularly since we shall be able to recover the nitrogen as ammonia, as a bye-product from the gasifying of the gas." He considered that the day was not far distant when, instead of the fuel being sent out as now sold, it would be disposed of solely in a gaseous form, and they would have in addition the nitrogen in the shape of ammonia.

We find the same feeling existing among ourselves, for we have heard Mr. George Shepard Page declare, in his lecture upon residual products, delivered before you at your last meeting, that, "With these new products that are being obtained, we may soon expect to realize what the late Dr. Letheby said would be the result in the future, although he might not live to see it, when 'gas would be the residual product.' Had his life been spared to the age of many I see before me, Dr. Letheby would have witnessed the fulfillment of his phopheey."

And again, we find that Mr. Thos. Butterworth, President of the Western Gas Association, made the following pertinent remarks in the delivery of his inaugural address at the meeting of the Association in May last: "I am credibly informed that some of our English brethren are so taking care of the sulphur impurities as to realize from them the costs of labor in purification. Now, in Illinois alone we have 50,000 miles of gas coal formations, capable of turning out 7,000 tons to the acre, and each ton containing nearly 5 per cent. of sulphur. When we gas men take out that sulphur in a merchantable form (and some of us will yet find out how to do it), then by what name will we be known? Will it be gas men, sulphur extractors, tar and coke distillers, managers of sulphate works, or shall we be known as manufacturers of some one of the coal tar dyes that our friend Page names by the hundred? When these and other forms of impurities become a source of revenue—and they surely will in the near future—what then will be the selling price of good 16-candle gas? If it is not given away, it will be sold at a nominal sum—less than $1 per thousand cubic feet."

Indeed, the evidence is all around us that the feeling is general and widespread that in the near future we will see the entire cost of manufacturing gas repaid by the sale of residuals. It is stated that the Paris Gas Company have already succeeded in recouping themselves for the cost of manufacturing their gas by the sale of residuals; and we hear that some of the English companies derive from this source a revenue equal to 70 per cent. of the cost of their coal.

But this movement has already left the realm of theory and entered the domain of fact. Mr. Young, of Clippens, is now erecting works capable of distilling 350 tons of shale per day, for the purpose of producing heating gas and ammonia; and we find in the *Journal of Gas Lighting* of September 12, 1882, the statement that Messrs. R. Damster & Sons, of Elland, Yorks, England, are now erecting works for the carbonization of 100 tons of small coal daily, to begin with, for the purpose of obtaining tar and ammonia, which will be fully treated in the works. The gas will in this case be the residual product, and will not be prepared for sale, but will be used for heating the retorts. It is further stated that the contemplated establishment will cost £24,000, and that the engineers in charge are confident that the enterprise will be entirely successful.

It may now be asked, What about the new process of making water gas that we expect to hear about? To which I answer, The chief characteristic of the new process is the simultaneous production of excellent heating gas, ammonia, and carbonates of soda, and that the process is so wide and radical an innovation upon established usages and precedents that, for the sake of obtaining a fair consideration for what I have to propose, I have deemed it a safe, prudent, and wise course to dilate to some extent upon the subject of residuals, and to endeavor to impress upon you their great importance, hoping thereby to convince you that, if I am crazy upon the subject, there is method in my madness, and that I am at least in good company; for I have, as I have shown, the indorsement and support of some of the best and brightest intellects in the profession.

After many years of trial, the manufacture of water gas has been brought to a high state of perfection, but it is still defective in two very important particulars.

In the first place, it cannot be denied that the very large percentage of carbonic oxide which it contains is at least very objectionable, not only on account of the well known poisonous qualities of this gas, but also on account of its injurious effect upon luminous flames; it being well known that gas lights in which this gas is largely prevalent are easily blown out, to which cause many of the deaths occurring through the inhalation of this gas are attributed by some. Besides this, no residuals are produced in the manufacture of water gas; and it must be admitted that this is a most serious drawback at a period when gas engineers the world over are expectantly looking for the coming of the good time when they can recover most, if not all, of the cost of manufacturing their gas by the sale of the residuals produced in the process.

The process of manufacturing water gas which I am about to introduce to you completely remedies these defects, by producing a water gas free from carbonic oxide, and at the same time residuals sufficient to repay the entire cost of manufacturing and distributing the gas twice over.

I shall now describe as briefly as I consistently can my process of making water gas, and at the same time producing ammonia and bi-carbonate of soda.

Let us first take a brief review of the state of the gas manufacture at present. First, we have the gas men who would gladly convert the carbonic oxide in their gas into carbonic acid, which they could easily do without loss of volume, if it were not for the large volume of carbonic acid which they would be compelled to remove by lime, and which would consequently be a curse to them. They endeavor, consequently, to manufacture, as a basis for an illuminating gas, a water gas consisting as far as possible of hydrogen and carbonic oxide, and containing as small a percentage of carbonic acid as possible.

Next we have the manufacturing chemists who make cyanide of potassium and ammonia, and who produce in the process immense volumes of carbonic oxide, carbonic acid, and hydrogen, and, for the most part, let these gases escape from their furnaces; and yet the gas men, as I have just stated, are erecting expensive works, and expending large sums of money for the purpose of conducting a process the main object of which is to produce these waste gases of the manufacturing chemists.

And, again, we have the soda manufacturers, at least those of them who

use the ammonia-soda process, and whose number is constantly on the increase, who go to great expense to manufacture the carbonic acid which is the curse of the gas men, and which the chemists throw away; they at the same time buy ammonia from the gas men.

It will be readily seen how intimately these three industries are interlinked with and allied to each other, and how ridiculous it is that each of them should be throwing away as a nuisance just what the others are going to great trouble and expense to get; and I have no doubt that you will be greatly surprised to learn that the carbonic alone which may be produced in the water gas manufacture may be made to pay much more than the entire cost of making and distributing the gas, leaving the gas itself free, and with it many hundreds weight of ammonia for every ton of coal used.

I propose to produce, by a simple and continuous process, a water gas consisting of nearly pure hydrogen, and, simultaneously with it, large quantities of ammonia and bicarbonate of soda, the carbonic acid evolved in the process being combined in the latter salt, and becoming the most valuable product which I have, instead of being a curse as at present.

First. I make a cheap heating gas trough the action of steam and air on incandescent carbon. This gas will contain so large a percentage of nitrogen as to be unfit for illuminating purposes. I call it "generator gas."

Second. I convert into ammonia the nitrogen of the generator gas produced in the first part of the process, or at least the greater part of it.

Third. I convert into carbonic acid all the carbonic oxide produced in the process, and replace it by an equal volume of pure hydrogen.

Fourth. I remove the carbonic acid from the gas by means of the ammonia produced in the second part of the process, producing bicarbonate of ammonia.

Fifth. I decompose the bicarbonate of ammonia formed in the fourth part of the process by means of chloride of sodium (common salt), producing chloride of ammonia and bicarbonate of soda.

I shall now describe each of the above five processes in detail, showing as I go its connection with those which have preceded it and those which are to follow.

In June, 1878, there appeared in the American Gas Light Journal the report of a lecture upon a new method of producing cheap heating gas for domestic and manufacturing purposes, delivered before the British Society of Arts by Mr. S. W. Davies, and the statements made were so very startling as to attract my attention strongly.

This gas was said to be obtained by the action of steam and air upon incandescent carbon contained in a close chamber or cupola, the action of which was continuous instead of being intermittent, as the ordinary process of making water gas is. The composition of the gas produced was about as follows:

Carbonic oxide	22.6 per cent.
Hydrogen	10.0 "
Light carburetted hydrogen	4.9 "
Carbonic acid	4.5 "
Nitrogen	58.0 "
	100.0 per cent.

Mr. Davies' estimate was that 10 pounds of anthracite coal were capable of producing 1,000 cubic feet of this gas, which would be at the rate of 224,000 cubic feet to the ton.

From some things which had come to my knowledge I was disposed to regard the above statements as considerably exaggerated. I could not help feeling, however, that if the yield of gas was anything like it was represented to be, and the nitrogen, or at least a very large percentage of it, could be eliminated from it, it would be the cheapest basis for an illuminating gas that the world had ever seen.

I paid little attention to the matter, however, until 1879, when a series of articles upon generator furnaces appeared in the *Journal of Gas Lighting*, from which they were reprinted in the American Gas Light Journal. These articles gave the results of a series of experiments which had been conducted during a period of more than two years by a committee of the German Gas Light Association; and the statements which they contained appeared deserving of the most implicit confidence, their correctness being vouched for by Grohn, Bunte, Schiele, and Schilling, all engineers of the very highest standing.

These experiments showed that under suitable conditions an average result of 1 cubic meter of generator gas might be produced from 0.145 of a kilogramme of coke, or at the rate of 248,505 cubic feet of gas from one ton; its average composition being about as follows:

Hydrogen	13.70 per cent.
Carbonic acid	10.33 "
Carbonic oxide	17.33 "
Nitrogen	58.64 "
	100.00

A reference to the diagram at *a* will show the formation of this generator gas, it being seen that the oxygen of the steam and air is set free and combined with the carbon to form carbonic oxide and carbonic acid, while the hydrogen of the steam and the nitrogen of the air are respectively set free.

It may not be amiss to state here the means by which I have arrived at the weight of coke and the products derived from it as shown in the diagram.

Taking the German experiments as the basis of my calculations, and dividing the 248,505 cubic feet of gas produced from a ton of coke, according to its component parts, I find the following results:

Hydrogen.....	13.70 per cent.	=	34,045 cu. ft.	and weighing	180 lbs.
Carbonic acid..	10.33 "	=	25,670 "	"	3013 "
Carbonic oxide.	17.33 "	=	43,105 "	"	3198 "
Nitrogen.....	58.64 "	=	145,685 "	"	10854 "
	100.00 per cent.	=	248,505 cu. ft.	and weighing	17245 lbs.

Taking now the weight of nitrogen produced, 10,854 lbs., I find, by a simple calculation, $10{,}854 \times 12 \div 14 = 9{,}303$ lbs. as the weight of carbon which would be required for the complete conversion of this amount of nitrogen into cyanogen, and adding to this the weight of the coke already consumed in making the generator gas, I have $2240 + 9{,}303 = 11{,}543$ lbs. $= 5.153$ tons of coke or carbon used in the entire process.

In order to find the entire product derived from one ton I now divide the entire weight of coke used, as well as the quantities and weights of the generator gas produced, and of its component gases, by 5.153 as a common divisor, and in this way arrive at the products given in the diagram, viz., 430 lbs. of coke used for making generator gas, and 1804 lbs. used in converting the resulting nitrogen into cyanogen, etc.

In the case of the German, as well as of the English experiments heretofore mentioned, the large percentage of nitrogen present in the gas would evidently render it unfit for use for illuminating purposes; but, at the same time, it became obvious in both cases, that if this nitrogen could be removed, it would afford an extremely cheap basis for an illuminating gas.

Up to this time, like many of you I presume, I had paid but little attention to nitrogen or its compounds, and indeed felt no interest in it, looking upon it as an inert, unmanageable gas, which had little affinity for anything, and was of little account, at least so far as gas making was concerned.

I continued to think over the matter, and the more I reflected upon it the more I became convinced of the great value of any process by which I could eliminate nitrogen from generator gas produced by the action of air and steam upon incandesecent carbon.

I commenced to study up the nitrogen question with a will, and for the next 18 months devoted all my spare time to ascertaining the best means for eliminating it from generator gas. I rummaged the libraries for information, hunting up such old records and papers as I thought would assist me, and searching, often for weeks at a time, through the technical and scientific periodicals and the proceedings of learned societies, in the hope of finding something that would throw light upon the subject.

I was rewarded, since I found much more than I hoped for when I started out—but nothing connected; all I found consisted of mere fragments of intelligence and records of half-tried and forgotten experiments scattered here and there through the patent and scientific records of the past 40 years. The results of my searches, however, were to convince me that the only practicable plan of eliminating nitrogen from the gas was to convert it into ammonia. Well, as I have already stated, the second step in my process is to convert the nitrogen of the generator gas into ammonia.

When I started out to convert my nitrogen into ammonia, I had just a general idea of how to go about it. From the authorities which I had consulted I made up my mind that the task was quite feasible; but, beyond a few general statements, I could find nothing to assist me for a long time, nor could I learn that ammonia had ever been produced upon a practical scale from the combination of atmospheric nitrogen with hydrogen.

I learned, from "Wurtz's Dictionaire de Chimie," p. 484, that "nitrogen does not combine directly with hydrogen, but that it can unite itself with carbon at a red heat in the presence of an alkali or alkaline carbonate, and that it is a cyanide which is produced in this case." And again, p. 1171, that "the greater part of the cyanides—in a dry state—with the exception of those of mercury and copper, are pretty stable, and may be submitted to a red heat without decomposition, but in the presence of a little water produce carbonates and ammonia."

Again, p. 1075, that "when passed over carbonate of potassium heated to redness, cyanogen produces cyanide and cyanate of potassium; when the cooled mass is dissolved in water, the latter salt becomes converted into alkaline carbonates and ammonia."

And again, p. 1084, that "cyanide of potassium is formed when a current of gaseous nitrogen is passed over the hydrate or the carbonate of potash heated to a red heat."

From Wurtz, and other authorities which it is needless to quote here, satisfied myself upon several points—

1st. That ammonia cannot be produced, at least upon a practical scale, by the direct synthesis of its elements hydrogen and nitrogen.

2d. That there is no difficulty whatever in evolving ammonia from cyanogen and its compounds.

3d. That alkaline cyanides are easily formed at high temperatures by the combination of hydrogen and carbon with an alkali or alkaline earth.

4th. That while a very high temperature is required for the production of alkaline cyanides, these same cyanides may be decomposed by steam at a temperature of 600° F., with the production of ammonia.

5th. That the ammonia so formed at a temperature of 600° is decomposed at a red heat, and that consequently the range of temperature between the points of formation and decomposition is extremely narrow.

I was confirmed in my conclusions as to the formation of cyanides by Sir Robert Kane, who says: "Cyanogen may, however, be formed abundantly, and in a simple manner, by bringing its elements together at a high temperature in contact with substances with which it may unite itself. When any organic substance containing nitrogen is calcined with potash the nascent carbon and nitrogen unite, and cyanide of potassium is formed." And by Watts, who tells us ("Chemistry," Vol. II., p. 203) "that cyanides can be formed by passing atmospheric nitrogen over carbon impregnated with potash, has been sufficiently proved by several experiments, especially those of Havens and Bunsen (p. 198); and it has also been found possible to carry out this mode of formation on a manufacturing scale.

"Possoz and Boissiere first established a manufactory for this purpose at Grenelle, near Paris, in 1845, but subsequently transferred their operations to Newcastle, England, where fuel could be obtained at a much smaller cost. Their process, improved by Bramwell, of Newcastle, consisted in passing a current of air for 10 hours over charcoal powder saturated with carbonate of potassium, and contained in wide earthen cylinders placed in an upright position.

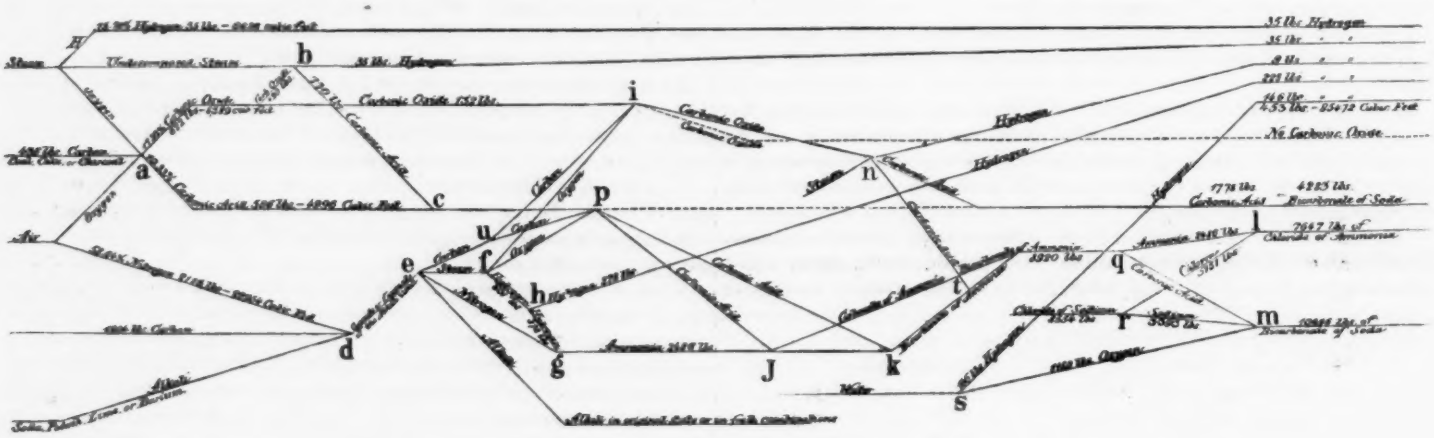
"The factory was in operation for two years, during which it produced 1,000 kilogrammes (about a ton) of yellow prussiate daily. It was, however, not found to work profitably, and was ultimately abandoned, chiefly, it appears, on account of the large expenditure of fuel, and because the cylinders (retorts), whether of fire-clay or iron, were unable to stand the intense heat to which they were exposed."

Here was really something encouraging. Not only was the process of manufacturing ammonia by combination of its elements theoretically practicable, but I here found, upon the most indubitable authority, that cyanide of potassium, a recognized source of ammonia, had actually been manufactured upon a practical scale for a lengthened period, as I subsequently found confirmed by a paper read by M. Possoz himself before the French Academy of Science. (See "Bulletin de la Societe de l'Encouragement, and Comptes Rendus," for 1848.) I searched also for the French patents under which MM. Possoz and Boissiere started their operations in France, and was agreeably surprised to find in them more solid information upon the subject of manufacturing ammonia from atmospheric nitrogen than I had been able to derive from every other source combined; so much so that further investigation, as well as my own subsequent experiments, more than warrant me in pointing to these patents as a most reliable source of information upon the subject of manufacturing ammonia from atmospheric nitrogen. They are No. 9,536, issued to MM. Possoz and Boissiere on December 24, 1843, and No. 1,183, issued to M. Possoz on October 1, 1845, and deserve the closest study and attention from any person interested in the subject either of manufacturing ammonia in the process of making water gas, as I propose to do, or of increasing the yield of ammonia in the process of manufacturing coal gas.

I have so far dwelt at length upon the various steps through which, without any previous knowledge upon the subject, I gradually studied out and formulated for myself a process for converting the nitrogen in the generator gas, produced in the first part of my process, into ammonia, partly with the idea that a plain statement such as I have made, and the references which I have given, would be of assistance to those who wish to investigate the subject for themselves, and partly with a view of satisfying you that what I have done in this matter has been the result of quiet and patient investigation.

I am disposed to dwell upon the method of converting nitrogen into ammonia for the reason that this is the only part of my process which is at all strange to you, for the American Gas Light Journal has familiarized you all with the remaining parts thereof, and also for the further reason that this is the keystone of the whole process, and that consequently it is of importance that you should fully comprehend it. Indeed, the process of converting free nitrogen into ammonia, as I propose, is not by any means so strange or new as many of you would suppose, for it is merely a repetition upon a larger scale of the process by which all the ammonia produced in the manufacture of coal gas is obtained, with this difference, that where, even under the best conditions, you accidentally produce about 25 pounds of sulphate of ammonia from a ton of coal, I derive from the same ton of coal, and by the identical reactions which take place within your retorts, two hundred times as much.

It is well established that bituminous coal does not contain ammonia already formed, but that it does contain the elements of cyanogen, and also of ammonia—a ton of coal usually containing from 50 to 75 pounds of nitrogen and a few pounds of alkalies, magnesia, lime, soda, and potash. So much has been ascertained, although it is not well known in what shape exactly the nitrogen is combined in the coal. So that we have in the gas retort all the elements required for the production of cyanogen, the carbon, the nitrogen, and the alkali all contained in the coal itself. And further, we have in the watery vapor which is continually given off during distillation, steam for the decomposition of the cyanogen and the formation of ammonia.



Is not this just the same as I do, except that instead of trusting to the 50 or 60 pounds of nitrogen and the few pounds of alkali contained in the coal for the production of ammonia, I furnish to and bring into intimate contact with the coal all the nitrogen and alkali necessary for its complete conversion into cyanogen, and which I afterward decompose by steam, with the production of ammonia?

Have you formed any idea of the quantity of ammonia that may be evolved out of the cyanogen produced from the carbon in one ton of coal, assuming the latter to be about 1,800 pounds? Why, about 2,500 pounds of ammoniacal gas, equivalent to the production of 9,705 pounds of commercial sulphate of ammonia. And it is only necessary to study, and to endeavor to reproduce as nearly as possible the reaction which takes place within your retorts to obtain a very large percentage of this. I do not pretend to tell you that you can get it all, but I have reason to believe that by good management it is possible to get at least one-third of it; and I need not tell you that if you get even the tenth or twentieth part of it you will then have a big thing.

You may now tell me that this is all very well in theory, but that it is impossible to put it into practice. Have we not the most incontrovertible evidence that during a period of more than two years Mr. Bramwell successfully manufactured cyanide of potassium upon a large scale in England? And as evidence of the growing hold which the idea of producing ammonia by the synthesis of its elements has taken upon men's minds, have we not the fact, as already stated, that Mr. Young, of Clippens, has already succeeded in raising his yield of ammonia from 25 to 75 pounds per ton of coal, and is even now making improvements by which he expects to raise his yield to 112 pounds of ammonia and 50,000 cubic feet of water gas to the ton of coal. Nor does it look altogether like theory that Messrs. R. Dempster & Sons are

even now erecting, at a cost of not less than £24,000, works in which ammonia will be the manufacture and gas the bye-product. Nor does it look mere theory to me that I have repeatedly tried the thing myself in a small and imperfect apparatus, where it was absolutely impossible to produce a sufficiently high heat or to maintain suitable conditions, and that I have repeatedly taken generator gas containing 60 per cent. of nitrogen, and, after passing it through a small retort, have found this nitrogen reduced to less than 20 per cent.

Is it anything more wonderful that ammonia should be produced by the synthesis of its elements than that beef fat should be chemically changed into butter, or that grape sugar should be artificially produced? Is it any more wonderful than the telephone? And yet any person who would have dared ten years ago even to hint that it was possible to converse with a friend 20 miles away would have been laughed at as an idiot. And, for all that, some how or other all these things have come to pass, and are now such old stories that even the children have ceased to wonder at them.

One thing is certain: the foremost men in the profession unhesitatingly declare that the day is not far distant when gas will be the residual product. The idea is daily growing and taking a stronger hold on men's minds; and the experience of the world is that, whenever the leading men in any business or profession have unanimously fixed their minds upon a certain objective point, then some of them are sure to reach it within a little while. And never in the history of gas lighting have men's minds been directed more earnestly than they are now to the best means of obtaining an increased yield of ammonia.

In this respect it may be well worth our while to consider whether it would not pay those of you who are engaged in the manufacture of coal gas to follow the lead of your English brethren, and to endeavor, as they are doing, to increase your yield of ammonia according to the system of Mr. Young, whose efforts in this direction have been attended with the most unqualified success; which may be well believed when we are assured, upon excellent authority, that the ammonia produced, even in the best conducted works, ranges from one-sixth to one-tenth of what may be obtained from the nitrogen contained in the coal, on which subject Lunge, in his late work on the distillation of coal tar and ammoniacal liquor, states, upon the authority of Dr. C. Maymoth Tidy, and also, I think, of the late Dr. Letheby, that the nitrogen contained in various samples of coal examined by him was capable of producing from 142 to 226 gallons of ammoniacal liquor of 4 degrees Twaddle per ton of coal, whereas, instead of this possible yield, rarely more than 45 gallons of gas liquor, of 4 degrees Twaddle, is obtained per ton of coal—usually 25, in London only 13 gallons.

The reactions by which cyanogen is produced, and is afterward converted into ammonia with the production of additional volumes of carbonic acid and hydrogen, are shown upon the diagram by the letters *d*, *e*, *i*, *u*, *p*, *e*, *f*, *h*, and *g*.

I should here state that before proceeding to the third part of my process, which involves the subjection of the gas to such a heat as would be destructive to my ammonia—this gas being decomposed and resolved into its elements at a red heat—I pass the gas through suitable condensers and scrubbers, in the latter of which my ammonia combines with the carbonic acid in the gas to form soluble carbonates of ammonia, which escape from the scrubbers as ammoniacal liquor.

The third part of my process relates to the conversion of the carbonic oxide in the gas into carbonic acid, with the liberation of a volume of hydrogen equal to that of the carbonic oxide removed.

I effect this by causing the carbonic oxide to decompose incandescent steam, which it readily does, combining with the oxygen of the steam to form carbonic acid, and liberating its hydrogen; the volumes of the carbonic acid produced, and of the liberated hydrogen, being in all cases each equal to that of the carbonic oxide removed; so that it will be perceived that there is no loss of gas in the process, but on the contrary a large increase, the carbonic oxide being replaced by an equal volume of hydrogen, and at the same time converted into a similar quantity of carbonic acid. There is nothing new or experimental in all this, for it was all done at Narbonne, in France, as far back as 1854, when Fayes succeeded in constructing an apparatus in which water gas practically free from carbonic oxide was made upon a practical scale for several years. (See historical notice of lighting by water gas in La Genie Industriel, Vol. II., p. 148. See also Vol. XVII., p. 1, where you will find the following analysis of the water gas produced at Narbonne:

Watery vapor	3 per cent.
Carbonic acid	3 "
Carbonic oxide	2 "
Carburetted hydrogen	1 "
Hydrogen	89 "
Loss	2 "
	100

Verver's analysis states the composition of the Narbonne water gas to have been as follows:

Watery vapor	1.02 per cent.
Carbonic acid	.50 "
Carbonic oxide	3.54 "
Light carburetted hydrogen	.38 "
Hydrogen	94.08 "
Nitrogen	.12 "
Loss	.36 "
	100.00

For a full report on this gas see *Journal fur Gasbeleuchtung* for 1859, page 372, and 1861, page 90.

Indeed, it is well known that the manufacturers of water gas would gladly avail themselves of the process just described of removing all the carbonic oxide from their gas and replacing it by an equal volume of pure hydrogen, were it not for the enormous quantity of carbonic oxide produced, and which they would subsequently be compelled to absorb by lime, the great expense of which naturally deters them.

Just imagine the quantity of lime required for the absorption of the carbonic acid produced by the complete combustion of one ton of carbon. $2240 \times 22 \div 6 = 8{,}213$ pounds, which, multiplied by 8.52, gives 69,973 cubic feet of carbonic acid as the product of the perfect combustion of one ton of carbon.

Now, a pound of lime cannot absorb more than 6 cubic feet of carbonic acid, and consequently we have $69{,}974 \div 6 = 11{,}662$ pounds of lime as the quantity required for the complete absorption of the carbonic acid produced by the perfect combustion of one ton of carbon, which is manifestly too much of a good thing.

While there is nothing new or experimental in the simple conversion of carbonic oxide into carbonic acid, with the liberation of an equal volume of hydrogen, there is most decided novelty in the process of first making ammonia with which to remove the enormous volume of carbonic acid produced in the process, and in subsequently converting the latter into a valuable product, as will be presently seen.

The reaction whereby the carbonic oxide of the gas is converted into carbonic acid, with the liberation of an equal volume of hydrogen, is shown upon the diagram by the letter *n*.

The fourth part of my process relates to the purification of the gas from carbonic acid by means of the ammonia produced in the process itself—the ammonia and carbonic acid being caused to combine and to form soluble carbonates of ammonia.

There is little necessity for me to say to you that there is nothing new in absorbing carbonic acid by means of ammoniacal liquor, for this is well known to gas men, the principle of the process being that, when a gaseous mixture containing ammonia and carbonic acid is caused to pass in a cool state through wet scrubbers, these gases combine, the ammonia being compelled to absorb a double equivalent of carbonic acid; so that there is no difficulty in relieving gas from this impurity by means of ammonia when even a half equivalent of the latter gas is present, and even very much less than this quantity may be made to serve for the complete purification of the gas from carbonic acid, by having recourse to the well known principle of regenerating or recovering the ammonia at the end of the process, which may be easily effected by boiling the chloride produced in the fifth and last part of the process with milk of lime, as practiced in the ammonia-soda process, where the same ammonia, less five per cent. loss each time, is used over and over again all the while.

On the subject of ammoniacal purification of gas, I would refer you to the American Gas Light Journal, Vol. XVII., pages 24 and 118, and Vol. XXVII., page 175. Also see page 178, same volume, where Mr. Livesey uses these words: "The great thing to be desired is more ammonia." And again, same page, where Mr. Hunt says: "There is nothing really new in Messrs. Wallace and Claus' process in regard to the carbonic acid, but simply with regard to the supply of ammonia—there was the difficulty." And again, on page 179 you will find Mr. Livesey saying: "There was the fact that they had not nearly enough ammonia to purify the gas."

So you see that there is nothing very strange or experimental in my proposition to purify my gas from carbonic acid by means of ammonia, and that the great novelty consists in providing ammonia enough to do the work.

The purification of the gas from carbonic acid by means of the ammonia in the gas itself, with the formation of bicarbonate of ammonia, is shown upon the diagram by the letters *j*, *k*, and *t*.

It may be observed, at the same time, that the carbonic acid which enters into combination with ammonia, as shown at *j* and *k*, is insufficient for the conversion of the entire ammonia into bicarbonate, and that the additional volume of carbonic acid produced from the carbonic oxide, as shown upon the diagram at *n*, not only supplies this deficiency as shown at *t*, but, in addition thereto, leaves an excess of 1,778 pounds of carbonic acid to be afterward treated by regenerated ammonia, as already described.

The fifth part of my process consists of the decomposition of the bicarbonate of ammonia produced in the fourth part of the process, by means of chloride of sodium (common salt), with the production of chloride of ammonia and bicarbonate of soda.

It cannot be said that there is anything new or experimental in this, as it is nothing more or less than the ammonia-soda process which is now so well known, and which is carried on most successfully, upon a large scale, in many places in Belgium and England. (See Lunge, on "The Manufacture of Sulphuric Acid and Alkalies," Vol. III., p. 33.) There you will find that, in 1878, M. Solvay, a Belgian manufacturer, produced 50,000 tons of soda of a superior quality by this process. Also, if you will refer to the Report (part I., p. 180) for 1880, of the Iron and Steel Institute, you will find that this same Solvay finds his business of making soda by this process so very profitable that he can afford to transport ammoniacal liquor 300 miles by rail for use in the manufacture of soda. In addition to purchasing ammoniacal liquor for use in the soda manufacture, and hauling it 300 miles over railways, M. Solvay manufactures carbonic acid for use in the process; and, on account of the difficulty of procuring ammonia at a reasonable price, is now, as I am informed, beginning to manufacture it himself.

The most attractive feature of the soda-ammonia process, as used in conjunction with mine, is that so far from finding my carbonic acid a curse and a source of expense, I, by this means, convert it into the most valuable product I have, inasmuch as I am thereby enabled to transform two pounds of rock salt, worth less than one cent, into one pound of bi-carbonate of soda worth five cents, an operation which, owing to the great quantities produced, will of itself more than repay the entire cost of making and distributing the gas, leaving the ammonia and gas itself free.

The reactions which take place between the bi-carbonate of ammonia and the chloride of sodium, as just described, are shown upon the diagram by the letters *q*, *r*, *l*, and *m*.

I have shown upon the diagram the weight and volume of the various products capable of being obtained as ultimate results from the perfect conversion of the material used, basing my calculations upon the well-known equivalents of the various bodies involved in the reactions produced.

It must not be supposed from this that I believe myself, or would have you believe, that the results as given, or anything like them, can be obtained in practice; but the ultimate results of perfect reaction in the several parts, and of the perfect conversion and utilization of one ton of coal and 8554 lbs. of rock salt, as calculated from the chemical equivalents of these bodies, would be as follows:

85,472 cubic feet of hydrogen, worth 25 cents	$ 21.36
15,289 lbs. bicarb. soda worth 5 cents	763.95
7,647 lbs. chloride of ammonia, worth 5 cents	382.35
	$1167.66

These figures may well startle and astonish you as I confess they startled and astonished me when I first attempted to formulate the chemical reactions of the process, as shown upon the diagram, and to calculate the results and products; but as I have already said I have no expectation, nor is there the slightest hope, that these results, or anything like them, can ever be attained in practice. There is, however, excellent reason to suppose that at least one-third, perhaps one-half, of the ultimate results can be reached in time; for the experience of the world proves that whenever men become convinced that a valuable prize is within the possibilities they find some means of obtaining it.

It will be perceived that in estimating the ultimate results of one ton of coal or coke I have made no allowance whatever for the fuel used in producing reactions which require that large volumes of gas should be heated and cooled twice over and, in addition thereto, that great quantities of ammoniacal products should be crystallized from their solutions by heat.

It is proposed to use the generator gas itself for fuel, and I think that half of this will be a liberal allowance for that purpose, which would reduce the products obtained to one-half the above quantities, so that we would have, as the product of one ton of coal or coke and 4277 lbs. of coarse salt, the following products:

42,736 cu. ft. of hydrogen, at 25 cents per 1000	$ 10.68
7,644 lbs. bicarb. soda, at 5 cents per lb	382.20
3,823 lbs. chloride of ammonia, at 5 cents per lb	191.15
	$584.03

You may now with justice ask—what reason have you for the faith that is in you when you tell us that there is excellent ground for hope to suppose that certainly one-third, and possibly one-half, of these enormous products can be obtained at the cost of one ton of coal and 4277 lbs. of coarse salt, plus the cost of labor?

Careful investigation of the methods pursued in former times to produce ammonia from atmospheric nitrogen leads irresistibly to the conclusion that they were wasteful and extravagant, for the first efforts in this direction were confined altogether to the practice of producing the required reactions by the application of heat to close retorts containing the material operated on. We learn, however, from M. Possoz, that all attempts in this direction were failures. To use his own words:

"In order to heat the entire mass (of carbon and alkali) to the point necessary to the production of cyanogen, it became necessary to heat the retort externally to such a point that in a little while it became full of holes or cracks, or otherwise useless; and, finally, in practice it was found impossible to heat uniformly a mass the center of which was always cooler than the sides, for the white heat had to traverse not only the thickness of the wall of the retort, but moreover the thickness of the alkalized carbon between the sides and the center, so that in order to obtain the proper heat in the interior it was necessary to regulate the introduction of alkalized carbon to the retort very carefully (he used a vertical retort and continuous feed) because if the quantity introduced was too great in proportion to the heat very little cyanogen was got."

He found also that it took fifteen days to get a working heat upon his retorts, and that they frequently gave out in a week or two.

Moreover he used gas in a cold state, for he further says, "I was obliged to force through this mass (of incandescent carbon and alkali) a current of gas the temperature of which was always much less than that necessary for the production of alkaline cyanides, and the interior of the mass, that it cost so much trouble to heat, was thereby being continually cooled."

You will easily perceive that the cause of failure here was in the attempt to heat a dense mass of fine carbon and alkali contained in a vertical retort, where it had every chance to pack itself, by external heat, and at the same time force a large volume of cold nitrogen gas through it; moreover, the retorts soon became leaky, and consequently, owing to the high pressure used for the purpose of forcing the gas through the dense mass of carbon and alkali in the retort, a great part of the gas passing through it was lost.

It will be seen that the failure here was altogether owing to defects in the construction and management of the retorts used, and not at all to anything in the process itself.

M. Possoz soon removed these difficulties, at least in a measure, by heating the nitrogenous gases destined for the production of the cyanogen to incandescence before admitting them to the furnace. He found such good results from the change that he soon learned to place his chief reliance upon the heating effect of the incandescent nitrogenous gas passing through the furnace for the production of cyanides, and to expect from the external fires little more than the retention of heat in the retort and fire-bricks around it.

This was the principle of heating adopted by Mr. Bramwell, of Newcastle, who, as has already been said, made a ton of cyanide of potassium daily for a period of more than two years. The business, as before stated, was found not to be profitable, and was finally abandoned. It must, however, be remembered in this connection that he threw away all his carbonic acid and heating gases.

It is strange that with all this experience upon record, and easily accessible to any person who would take the trouble to hunt it up, out of more than twenty English patents that I have consulted, for the manufacture of ammonia, all but two are based upon the principle of external firing, abandoned so long ago by Possoz, and that these two are the only ones which have hitherto given the slightest promise of successful development.

The wonderful state of perfection to which the system of superheating gases has been brought, in consequence of the introduction of the Siemens and other heating furnaces, and the equally wonderful results obtained in the combustion of pulverized fuel, and in the system of converting it into heating gas by means of superheated steam, as first introduced by Crutchett in 1865, and since brought to a high state of development by Strong, Dwight and others, appears to me to afford the true solution of the difficulties which have attended the earliest attempts to produce ammonia artificially from atmospheric nitrogen.

You are all aware that in what is known as the Strong system of making water gas steam is raised to a most intense temperature, by being caused to pass through a cupola containing a reticulated mass of fire-brick, previously raised to a white heat, and that the steam being thus raised to a high temperature, in passing through and in contact with the heated bricks, is caused to meet a falling shower of coal dust, which is automatically and continuously fed into the cupola, the effect of which is that the coal dust instantaneously, I should almost say explosively, decomposes the steam, producing carbonic oxide, carbonic acid, and free hydrogen. Experience proves that the gasification of the coal dust is much more perfect than when lump coals is used, and further, that it proceeds with three times the rapidity. The same principle is also successfully applied to the desulphurization of gold and silver ores.

A little reflection will show what a perfect analogy there is between the oxidation of pulverized coal by the oxygen of incandescent steam and the cyanization of pulverized coal and alkali by the nitrogen in incandescent nitrogenous gas, and that the system which has been applied with such marked

success in the manufacture of gas should produce equally good results in the production of cyanogen and alkaline cyanides.

Upon this head there is excellent reason to believe that the splendid results produced by the gasification of pulverized fuel by incandescent steam are but a tithe of what may be expected from the application of the same principle to the manufacture of alkaline cyanides as a step in the manufacture of ammonia.

As far as I have been able to inform myself, the greatest difficulty experienced by Bramwell was the caking or solidification of the mixed coal and alkali in his furnaces; and indeed my own experience has satisfied me that, under the ordinary conditions of practical work, it would be impossible to operate successfully upon a mixture of lump coal and alkali in an upright cupola or retort for the production of cyanogen; for when the alkali used is lime or salt, or a mixture of both, which, for economical reasons, will be found most suitable, it will settle down into the lower part of the furnace and actually choke it up, a defect which Bramwell attempted to remedy by surrounding his cupola with slots through which he could break up the compact mass within it.

As to the alkali best adapted to the production of ammonia and heating gas, I am satisfied that lime mixed with a little salt or slaked with a strong solution of salt will be found by far the most economical, and equally as effective as any other. It is true that nearly all the authorities upon the manufacture of cyanides from atmospheric nitrogen point to potash as the most suitable alkali for the purpose. But it must be remembered that, in all the former experiments in this direction, the object was the production of ferrocyanide of potassium, the reason of which was not that potassium was more suited for the production of cyanides than some of the other alkalies, but that most of the cyanides are very unstable and decompose very rapidly, while, on the contrary, ferrocyanide of potassium is very stable, on which account it has been looked upon as a most desirable combination in which to fix nitrogen.

I fear that I have already trespassed too much upon your valuable time, and feel that I owe you an apology therefor; but having devoted much time and experiment to the investigation of a process which, in many of its aspects, is entirely new, and the principles of which are in the closest union and accord with the ideas of the most advanced thinkers of the profession, I have been induced to enter into particulars perhaps more fully than was actually necessary, but not more so than is due to the importance of a subject which appears to engross a very large share of attention, especially in view of the competition of electricity and petroleum—chiefly the latter, and of the enormously increased consumption of gas which would be sure to follow such a marked reduction in the selling price as the adoption of this process would lead to.

If, however, I have succeeded in directing your thoughts into a new channel the attention which you have given me will, I hope, not be altogether devoid of fruit; for a germ, even of error, which is started into life frequently ripens into a rich and abundant harvest of truth and progress.

In the hope, then, that my effort may not be altogether unprofitable to you, and thanking you for your kind attention, I would close by asking for a calm consideration of the statements which I have made, and by again reminding you, in the words of Mr. Clegg, that "He is a bold man who, at the present day, condemns a new thing without very deliberate consideration, and he is an imprudent one if he accepts for truth anything that is advanced in favor of a new thing without the same precaution."

[To be continued.]

Electric Units.

By D. Monnier, C. E.

(Continued from page 179.)

In taking as the point of departure the unit of quantity, and in defining it as "a quantity which exercises a unit of force upon an equal quantity placed at a unit of distance," we have an electro-static system which is most favorable for the study of static electricity.

By taking as a point of departure a unit of current such that "the unit of length of the unit of current exercises a unit of force upon a unit of magnetic pole placed at a unit of distance," we have the electro-magnetic system, which is particularly adapted to the study of the phenomena of electricity in motion.

The three fundamental units adopted by the British Association for the Advancement of Science are the centimeter for length, the gramme for mass, and the second for time. This system has received the name of C. G. S. (centimeter, gramme, and second). In this system the unit of force, which is called "dyne," is the force which, acting upon a mass of one gramme during one second, impresses upon it an acceleration of one centimefer per second. The unit of work is called "erg," and is the work developed by a unit of force running through one centimeter of length.

Taking the acceleration due to the weight, $g = 9^{m}81$, we have—

1 kilogramme $= 9.81 \times 10^{5}$ dynes.

1 kilogrammeter $= 9.81 \times 10^{7}$ ergs.

We notice that in the C. G. S. system the units of force and of work are very small; so that the magnitude of the different electric units of the C. G. S. system is not in convenient proportion with quantities in practical use, and their employment would lead to a form of expression by numbers either very large or very small—*i. e.*, not convenient to manage. So that in place of using the absolute C. G. S. units it has been decided in practice to use multiples or sub-multiples of the absolute C. G. S. units.

The International Congress of Electricians, at their meeting of the 22d of September, 1881, fixed the following definitions for the usual electric units:

I. The adopted for electric measurements the fundamental units—centimeter, gramme (mass), and second—C. G. S.

II. The practical units—the "ohm" and the "volt"—preserve their actual definition, viz., 10^{9} absolute units C. G. S. of resistance equal 1 ohm, and 10^{8} absolute units of electro-motive force equal 1 volt.

III. The unit of resistance (the ohm) is to be represented by a column of mercury of one square millimeter cross section at a temperature of 0° C.

IV. An international commission is to be charged with the duty of determining, by new experiments, the length of a column of mercury of one millimeter cross section at a temperature of 0° Centigrade, which shall represent an ohm.

V. The "Ampere" is the current produced by a volt in an ohm.

VI. A "Coulomb" is the quantity of electricity defined by the condition that an "ampere" shall give one "coulomb" per second.

VII. A "Farad" is the capacity defined by the condition that a coulomb in a farad gives one volt.

From the above, then, we have—

1 volt $= 10^{8}$ C. G. S. units.

1 ohm $= 10^{9}$ C. G. S. units.

From the relation $C = \frac{E}{R}$, we have an ampere $= \frac{10^{8}}{10^{9}} = \frac{1}{10}$ C. G. S. unit of current. We see in the same way that a coulomb $= \frac{1}{10}$ C. G. S. units of quantity. A farad $= 10^{9}$ C. G. S. units of capacity. And finally, from the equation $W = QE$, we see that the unit of work in the system of practical units is equal in value to 10^{7} C. G. S. units of work (ergs).

Ohm. From experiments made by the commission of the British Association, the length of the column of mercury of one square millimeter cross section at zero (Centigrade) temperature which represents the ohm is $1^{m}.0486$. This is the actual value of the standards of resistance which we find in commerce. These standards are formed by threads or wires, made of an alloy of two parts of silver and one part platinum, because the resistance of these bodies varies very little with the changes of temperature. The metallic thread is insulated with care by several coverings of silk and then rolled on a bobbin. The rolling is done double, so that in each part of the bobbin there are two currents, which are equal and have contrary signs, and in this way the effects of induction on the magnets or the neighboring wires are avoided. In practical use are employed boxes of resistance coils, formed of a number of bobbins, of different resistances, giving multiples and sub-multiples of the ohm. The one in most common use will determine resistances varying from one to ten thousand ohms.

Volt. The volt is the practical unit of electromotive force. The standard for representing its exact value has not yet been constructed. The electromotive force of one Daniel element is about 1.079 volts. That of a zinc-chloride of silver element (Warren de la Rue) is equal to 1.068 volts. That of a zinc-mercury element (Latimer Clark) is 1.457 volts at $15\frac{1}{2}$°.

Ampere. Evidently it is not possible to have a material representation of the Ampere. The value of a current is determined in functions of properties acquired by the conductor that the current traverses.

The study of the action of currents upon magnets is called electro-magnetism; the study of the action of currents upon currents is called electro-dynamics; that of the action of currents upon chemical compositions is called electro-chemistry. These three classes of actions furnish three classes of instruments for the measurement of currents—the galvanometer, the electro-dynamometer, and the voltameter; and, finally, the calorimeter measures the energies of a current by the quantity of heat which it develops in traversing a conductor of known resistance.

[To be continued.]

Electric Lights a Nuisance.—The blazing electric lights in the City Hall Park are nuisances. They dazzle the eyes, and thereby increase the peril of crossing the crowded streets that border the park. Where they do give light they give too much, and at times they leave the park in darkness. The old gas lamps served the purpose much better, and made the park safer and more pleasant.—*N. Y. Sun.*

The Estimation of Sulphureted Hydrogen in Gas by Direct Weight.

At a recent meeting of the American Chemical Society, Mr. A. P. Hallock gave the results of some experiments on the determination of sulphureted hydrogen in gas. He first tried the absorption method with binoxide of manganese, but found that in cases where "the quantity of sulphur was comparatively small, and the amount of gas which could be used was also very small, the liability to error was so great that no satisfactory results could be obtained." Solutions of acetate of lead and sulphate of copper, in U-tubes were not found to work well, and the dehydrated sulphate of copper was experimented with. In this case the absorption was satisfactory, but the fine powder, to which the substance had been reduced, prevented the free passage of the gas through it. As a last resort the dehydrated sulphate of copper in a granular form was tried and found to answer very well.

The following is a description of the apparatus employed. It consisted first of a drying cylinder containing fused chloride of calcium, next to this attached a weighed 6-inch glass-stoppered U-tube containing the dehydrated sulphate of copper, a bit of cotton was put on the top of the sulphate in the U-tube to prevent any of it being blown out. To this U-tube was attached another U-tube containing soda-lime and chloride of calcium, to catch any carbonic acid and thereby enable one to determine it at the same time, and after this was placed a meter to measure the quantity of gas passed through the tubes, and from the meter was a tube leading to a small burner where the gas was burnt.

The object of the first chloride of calcium was to dry the gas, for any moisture would be caught in the sulphate of copper tube and weighed as sulphureted hydrogen.

The apparatus was first tried on the pipe leading from the hydrogen main; after letting a sufficient quantity blow out, to ensure that it was fresh gas, for when the gas was first turned on it failed to produce any stain on acetate of lead paper, showing that the sulphur was being removed from the gas by the iron rust in the pipe. Some time after it began to produce a stain, the apparatus was attached by means of a T-shaped pipe so that the gas could be kept burning all the time, and thus have the flow of gas up the iron pipe much more rapid, and thereby have it acted upon as little as possible.

The gas was allowed to pass very slowly through the apparatus, not over one foot in three hours; after one foot had passed, the U-tube was detached and weighed, and found to have increased 0.198 grammes in weight, which would give 315.51 grains of sulphuretted hydrogen in 100 cubic feet, or, 0.47 per cent. by volume. After this four more determinations were made, allowing only one-half foot to pass each time, and although in this case the results had to be multiplied by 200, they agreed very closely, as may be seen by the following table. The column marked A gives the increase in grammes of weight of the U-tube, B gives the number of grains of sulphureted hydrogen in 100 cubic feet, and C the percentage:

	A.	B.	C.
No. 1.....	1085	344.91	0.51 per cent.
No. 2.....	1100	339.52	0.52 "
No. 3.....	1110	342.59	0.52 "
No. 4.....	1105	341.00	0.52 "

Shortly after this, experiments were made upon the finished gas and it was found that the U-tube had gained more in weight than it did when using the unpurified gas, sometimes showing as much as 100 grains more in 100 cubic feet.

After a few attempts it was found that the sulphate of copper assumed a peculiar tint different from what had been noticed while working on the unpurified gas, and it was thought that the sulphuric acid liberated might in some way have acted upon some of the hydrocarbons. Some of the sulphate was taken out of the tube and treated with absolute alcohol, and also with ether; there was then obtained a peculiar oily substance apparently a mixture of hydrocarbons. As yet sufficient quantities of it have not been obtained to allow experiments upon it. This was sufficient to prove what caused the increase in weight of the T-tube and showed that it was not due to sulphureted hydrogen.

[It may be well to state that the gas experimented upon is what is known as "water gas." Steam is decomposed by means of ignited carbon, giving a mixture consisting principally of hydrogen and carbonic oxide. This is subsequently enriched with naphtha, and passed through heated retorts to "fix" the naphtha vapor. Unless very high heats are employed some of the vapor escapes decomposition, and this is liable to condense when favorable conditions are presented. Doubtless the "peculiar oily substance" mentioned by Mr. Hallock will be found to be similar in its nature to the oily condensations often found in the mains of companies using naphtha as an enricher. The vapor would naturally be arrested by the porous copper salt, in the same way that minute particles of tar may be detected in coal gas in which the condensation has not been sufficiently thorough.]—*Sanitary Engineer.*

Gas Works and Chemical Industry.

In commenting editorially upon the first return made under the "Alkali, etc., Works Regulation Act," the London *Journal* speaks the following:

"It was said by the illustrious Liebig that the degree of civilization of any nation might be accurately gauged by the record of the quantity of sulphuric acid consumed within its borders. This is, at first sight, a somewhat fantastic way of solving an abstruse problem; but the more carefully it is examined, the more completely does it satisfy all the conditions of a crucial test of economic progress. It was probably owing to reflection on this maxim of the great chemist that the late Earl of Beaconsfield, on an occasion which may not be forgotten, cited the returns of the chemical trade as affording the first evidence of a revival of commercial prosperity in this country. Be this as it may, the maxim itself contains a deep truth which is well worthy of consideration and remembrance. For what does the extensive use of sulphuric acid by any nation really signify? Simply that this commodity—itself a bye-product, and not long since wasted—is the chief agent whereby the waste and rubbish of the nation's industry is redeemed for other uses. A savage tribe spoil as much as they consume of the products of the earth which support their existence; and a people perfectly civilized may, without any great stretch of the imagination, be supposed not to waste anything. Between these extremes are to be found all the nations of the world at this time, and they are distinguished among themselves by the degree in which they approximate to the ideal of civilization.

"Speaking in the broadest possible sense, it is, of course, true that nothing is absolutely wasted in the earth, because the compensating action of decay and assimilation goes on unceasingly, and in the long run the balance is thereby maintained. The element of time is an essential factor of this process, however, and the duration of human life is too short for many of the unhasting operations of nature. Some device must therefore be adopted for reconciling natural processes with man's necessities, and this is precisely the sphere of utility where sulphuric acid is "indicated," as a physician would express it; for this powerful agent substitutes a process of rearrangement for one of apparent decay, and does in an hour the work of centuries. Thus the savage tribe already referred to may indeed fertilize the ground with the bones of animals on which they feed; but the process does not return any profit to them. By slow degrees the remains decay, a more luxuriant herbage springs up on the spot, and game is attracted there, perhaps to fall a prey to other hunters. A people more civilized than these will perhaps economize their waste to the extent of bringing bones and rags to market, and thereby obtain a return in another kind. Large quantities of this class of waste product are exported from the poorest countries of the continent of Europe, and are bought by other nationalities who know how to use sulphuric acid to advantage. This is pre-eminently the case in England, where, not content with pouring sulphuric acid upon our own waste heaps of bones, rags and rubbish, we buy for this purpose all of the same kind of commodity that can be obtained the world over. Hence, when a chemist comes to reflect on the greatness and wealth of this country, he is as likely to connect this result with the prodigal use of oil of vitriol by our countrymen, as with any of the more evident, but not more reliable means to the same end.

"It is not our intention to follow the different trains of thought suggested by such an apparently prosaic commodity as sulphuric acid, taken in connection with the very varied industries catalogued in the Local Government Board return. It will suffice, for the present, to remark the satisfactory evidence which it affords of the careful utilization of the bye-products of gas manufacture. At first no two occupations would appear to be separated more widely than those of supplying light to towns and fertilizing the soil of the country. Yet this return gives prominence to the fact that in the great majority of gas works in the United Kingdom the production of two commodities—the lighting and the fertilizing medium—goes on side by side. It is curious to find that in all British gas works, almost without exception, the production of a chemical manure is the accepted "second string" of manufacture. Surely, if the copious use of sulphuric acid be a sign of advanced civilization, a gas works where manure is also made, regarded from a sociological standpoint, must be in itself an epitome of the civilization of the nation! These are not idle thoughts; for it is allowable sometimes to take stock, as it were, of our industrial condition upon some other basis than that of immediate profit and loss.

"It might have happened that the secondary developments of gas supply had been in directions not always nor entirely beneficial to peaceful industry. In reality we see that these developments have resulted in placing gas makers prominently in the ranks of those benefactors of their species who help to make two blades of grass grow in place of one."

Natural Gas in Bloomington, Ills.—It is stated that a project is on foot the object of which is to light the town of Bloomington, Illinois, with natural gas. It is proposed to employ the gas from a large well which was recently discovered in that locality.

THE AMERICAN
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THURSDAY, NOVEMBER 16, 1882.

An Improved Gas Engine.

Mr. Christian Rohn, of Worcester, Mass., has, after repeated experiments, succeeded in designing a gas engine, of which we append the following particulars: The engine is double-acting, and very simple in construction, and the obstacles which have usually seriously interfered with the construction of double-acting gas engines have been successfully overcome. The valves are driven by eccentrics, and the friction of the several moving parts has been reduced to an extremely low figure. The mixture of gas and air is compressed to some extent before being admitted to the cylinders, or only sufficient to make it fill the cylinder in the time required. This gas engine can, it is said, with safety, be made of any size up to 1,000 horse power, making it a three-cylinder engine and using steel in its construction.

Mr. Rohn has also designed another gas engine, of the disc-engine principle, having six cylinders, and as the charge for each cylinder is exploded in succession once in every revolution of the engine, great regularity and uniformity in power and speed is expected.—*Exchange.*

The Efficiency of Washed Coal.

Though it is generally conceded now that wet bituminous coal will not make as large a quantity of steam in a boiler as dry coal, there are few figures to substantiate this. There have been firemen, and there are some now, perhaps, who insisted that their coal yielded better results after it had been liberally moistened than when dry; but of late that idea has lost ground, and, as a geneaal rule, has been condemned. A series of tests have recently been made at Bochum, Germany, which offer facts in place of theoretical considerations. A quantity of washed slack, holding 18 per cent. of water and 9.9 per cent. of ash, evaporated 5.7 pounds of water per pound of fuel, while the same coal, with only 3 per cent. of water, made from 8 to 8.5 pounds of steam. Making due allowance for moisture by reducing to a standard of like quantities of coal free from moisture, there is found to be a direct loss by using wet coal of 14 per cent.—*Scientific Press.*

The Connellsville Coke Industry.

The Pittsburgh *Manafacturer* has obtained from parties interested in the Connellsville (Pa.) coke industry the following facts respecting the magnitude of the business of that district:

The 8,000 coke ovens of the district have a daily producing capacity of 15,000 net tons. The most of the coke goes to the West and Northwest. Some of the most distant markets to which it is shipped are Colorado, Utah, New Mexico, and Arizona. Freight charges from these points range from $20 to $45 per net ton. It is mostly used in iron-making blast furnaces, and in the far west for smelting the precious metals, etc.; but it is also largely used in foundries and other works. Following is an analysis of Connellsville coke: Water, at 225°, 0.030; volatile matter, 0.460; fixed carbon, 89.576; sulphur, 0.821; ash, 9.113. The most amazing feature of this industry is the enormous waste of gas it involves, and of the bye-products that would be got were the gas saved and purified.

Gas Stocks.

Quotations by G. W. Close Jr., Broker and Dealer in Gas Stocks.
(with W. B. Scott & Co.,)
34 PINE STREET, NEW YORK CITY.

NOVEMBER 16, 1882.

☞ All communciations will receive particular attention
☞ The following quotations are based on the par value of $100 per share.

	Capital.	*Par.*	*Bid.*	*Asked*
Gas Co.'s of N. Y. City.				
Central	$466,000	50	75	85
Harlem	1,800,000	50	36	99
" Bonds	170,000			103
Manhattan	4,000,000	50	217	220
Metropolitan	2,500,000	100	179	182
" Bonds	658,000	..	106	108
Mutual	5,000,000	100	103	106
" Bonds				
Municipal	1,500,000	100	178	183
" Bonds	750,000		106	110
New York	4,000,000	100	114	116x
Northern	270,000	50	90	—
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	105	110
Citizens	1,200,000	20	65	70
" S. F. Bonds	320,000	1000	105	107
Fulton Municipal	3,600,000	100	—	75
Peoples	1,000,000	10	40	45
" Bonds	290,000	.	104	107
" "	250,000	...	88	90
Metropolitan	1,000,000	100	65	70
Nassau	1,000,000	25	50	53
" Ctfs.	700,000	1000	90	93
Williamsburgh	1,000,000	50	50	55
" Bonds	1,000,000	...	100	101
Richmond Co., S. I.	300,000	50	70	75
" Bonds	40,000	—	—	—
Out of Town Gas Companies.				
Buffalo Mutual, N.Y	750,000	100	72	75
" Bonds	200,000	1000	95	100
Citizens, Newark	918,000	50	—	—
" " Bds.	124,000	—	105	10
Chicago Gas Co., Ills			125	—
Cincinnati G. & C. Co.			178	180
Consolidated, Balt.			42	43
Bonds			107	—
East Boston, Mass	220,000	25	122	128
Hannibal, Mo	100,000	100	95	100
Hartford, Conn	700,000	25	120	128
Halifax N. S	400,000	40	148	150
Hamilton, Ontario	150,000	40	117½	
Jersey City	750,000	20	155	160
Jacksonville, Ill	120,000	50	100	...
Lewistown Maine	400,000	100	—	100
Laclede St Louis Mo	1,200,000	100	117	—
Montreal, Canada	2,000,000	100	186	187
New Haven, Conn		25	144	—
Oakland, Cal			32	33
Peoples, Jersey City		...	75	80
" " Bds.			...	...
Pittsfield, Mass			120	130
Rochester, N. Y		50	70	80
Wilmington, Del		50	174	...
Yonkers		50	30	32
St. Louis Missouri	600,000	50	250	254
San Francisco Gas-Co., S. Fr'isco Cal.			68	69
Toledo, Ohio			95	97
Troy, Citizens	600,000	100	—	—
Washington, D. C	1,500,000	20	215	220
" Scrip	375,000	15	245	250

The following gas stocks were sold at auction; 335 shares New York gas company, at 113⅜–114½; six shares Metropolitan gas company, of Brooklyn, N. Y., at 72¾; 300 shares Citizens gas company, Brooklyn, New York, at 69½; $2,400 certificates Nassau gas company, Brooklyn, New York, at 90—40 shares Nassau gas company, Brooklyn, N. Y., at 50.

Advertisers Index.

	Page
GAS ENGINEERS.	
William Farmer, New York City	246
G. Warren Dresser New York City	245
GAS WORKS APPARATUS AND CONSTRUCTION.	
James R. Floyd, New York City	243
T. F. Rowland, Greenpoint, L. I.	243
Delly & Fowler, Phila., Pa.	243
Kerr Murray Mfg. Co., Fort Wayne, Ind	243
Stacey Mfg. Co., Cincinnati, Ohio	253
Bartlett, Hayward & Co., Baltimore, Md.	243
P. Munzinger, Phila., Pa.	243
Morris, Tasker & Co., Limited, Phila., Pa.	243
Davis & Farnum Mfg. Co., Waltham, Mass	214
GAS AND WATER PIPES.	
A. H. McNeal, Burlington, N. J.	242
Gloucester Iron Works, Phila., Pa.	242
James Marshall & Co., Pittsburgh, Pa.	242
R. D. Wood & Co., Phila., Pa.	242
Warren Foundry and Machine Co., Phillipsburgh, N. J.	242
Mellert Foundry and Machine Co., Reading, Pa.	242
SCRUBBERS AND CONDENSERS.	
G. Shepard Page, New York City	
Jas. R. Smedberg, New York City	240
RETORTS AND FIRE BRICK.	
J. H. Gautier & Co., Jersey City, N. J.	240
B. Kreischer & Sons, New York City	240
Adam Weber, New York City	240
Laclede Fire Brick Works, St. Louis, Mo.	240
Brooklyn Retort and Fire Brick Works, Brooklyn, N. Y.	240
Borgner & O'Brien, Phila., Pa.	240
Gardner Brothers, Pittsburgh, Pa.	240
Henry Maurer, New York City	240
Evens & Howard, St. Louis, Mo.	240
Chicago Retort and Fire Brick Works, Chicago, Ills.	240
Taylor and Anderson, Cincinnati, Ohio	240
DIETERICH'S REGENERATOR FURNACE.	
Charles F. Dieterich, Baltimore, Md.	248
GAS METERS.	
Harris, Griffin & Co., Phila., Pa	246
American Meter Co., New York and Philadelphia	247
The Goodwin Gas Stove and Meter Co., Phila. Pa.	247
Helme & McIlhenny, Phila., Pa.	247
Maryland Meter and Mfg. Co., Baltimore, Md.	247
GAS STOVES.	
American Meter Co., New York and Philadelphia	239
VALVES.	
Ludlow Valve Manufacturing Co., Troy, N. Y.	

EXHAUSTERS.

P H. & F. M. Roots, Connersville, Ind..... 241
Smith & Sayre Manufacturing Co., New York City..... 241

GAS COALS.

Penn Gas Coal Co., Phila., Pa..... 245
Perkins & Co., New York City..... 244
Cannelton Coal Co., New York and Philadelphia..... 245
New York and Cleveland Gas Coal Co., Pittsburgh, Pa..... 245
Newburgh Orrel Coal Co., Baltimore, Md..... 245
Despard Coal Co., Baltimore, Md..... 245
Fort Pitt Gas Coal, Pittsburgh, Pa..... 244
Chesapeake and Ohio R.R Coal Agency, N. Y. City..... 245

GAS ENGINES.

Schleicher, Schumm & Co., Phila., Pa..... 248

STREET LAMPS.

J. G. Miner, Morrisania, New York City..... 213

PURIFIER SCREENS.

George D. Cabot, Lawrence, Mass..... 238

BURNERS.

G. Gefrorer, Phila., Pa..... 242
The Goodwin Gas Stove and Meter Co., Philadelphia, Pa..... 224

PURIFYING MATERIAL.

Connelly & Co., New York City..... 241

STEAM BLOWER FOR BURNING BREESE.

H. E. Parson, New York City..... 238

PROCESSES.

Gwynne Harris New York City..... 242
Strong Gas and Fuel Co., Yonkers, N. Y..... 238

GAS FIXTURES.

Mitchell, Vance & Co., New York City..... 241

CEMENT.

F. O. Norton, New York City..... 241

BOOKS.

King's Treatise..... 244
Gas Analyst's Manual..... 245
Scientific Books..... 242
Cathels' Gas Consumers' Manual..... 247
Fodell's Book-Keeping..... 247
Review of Gas and Water Engineering..... 247

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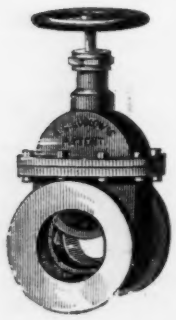

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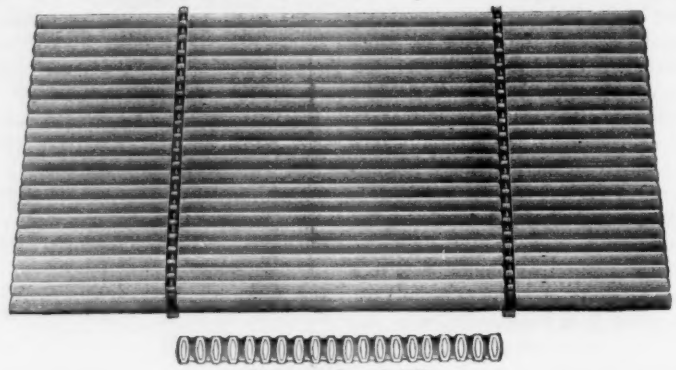

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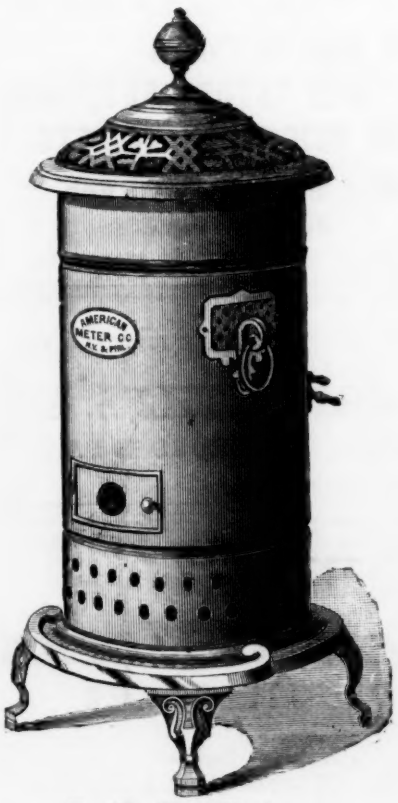

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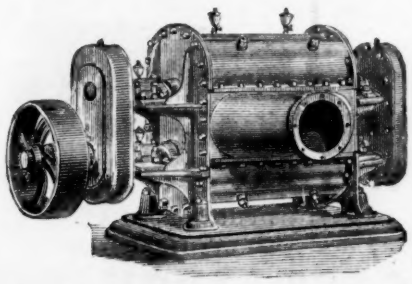

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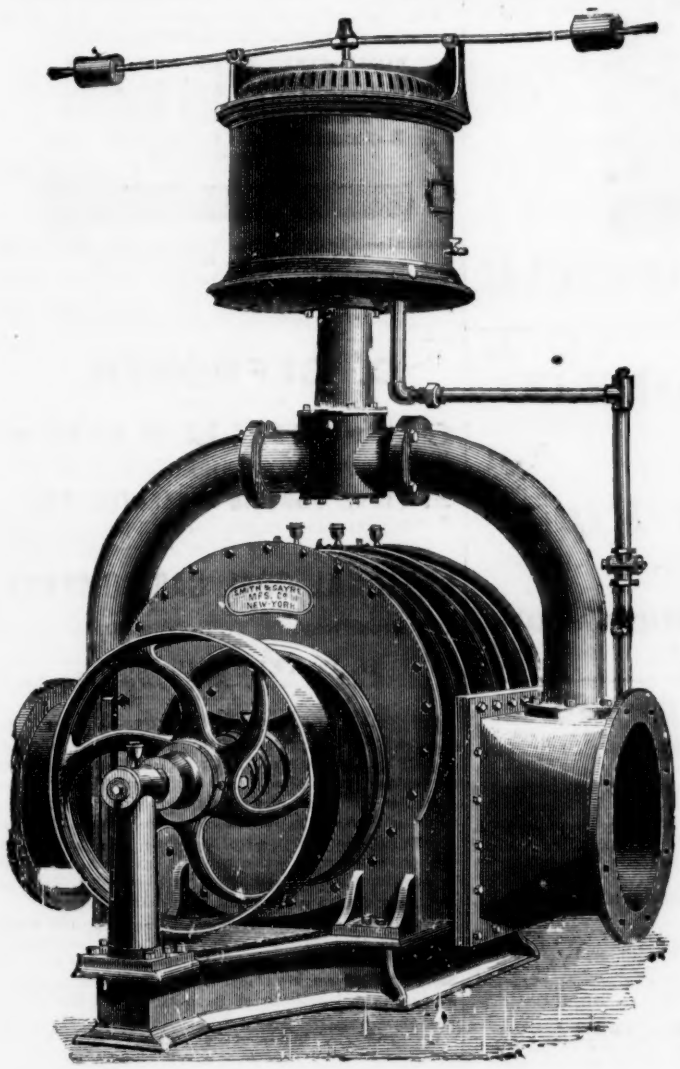

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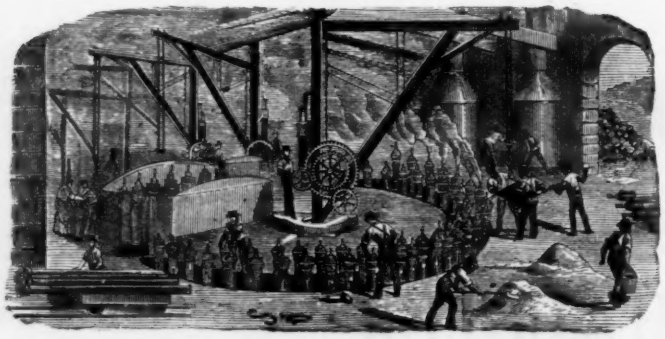

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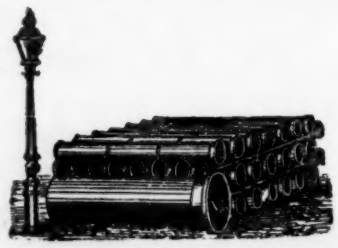

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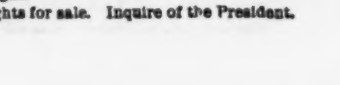

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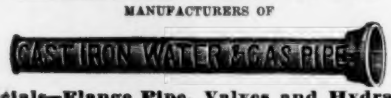

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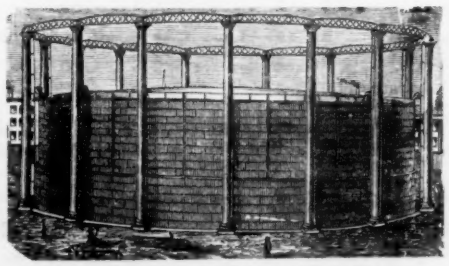

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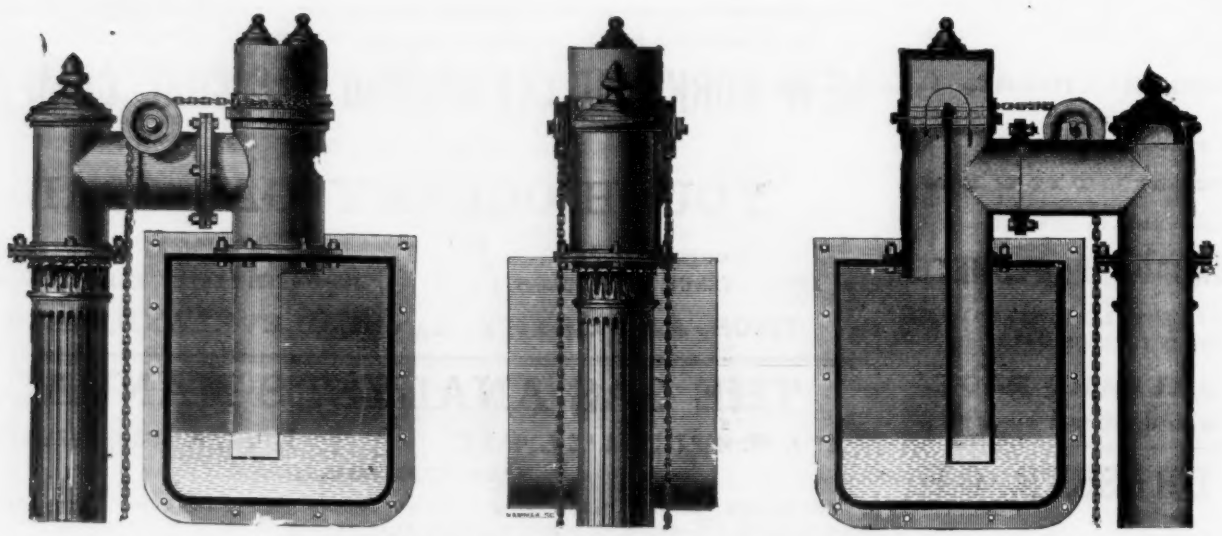

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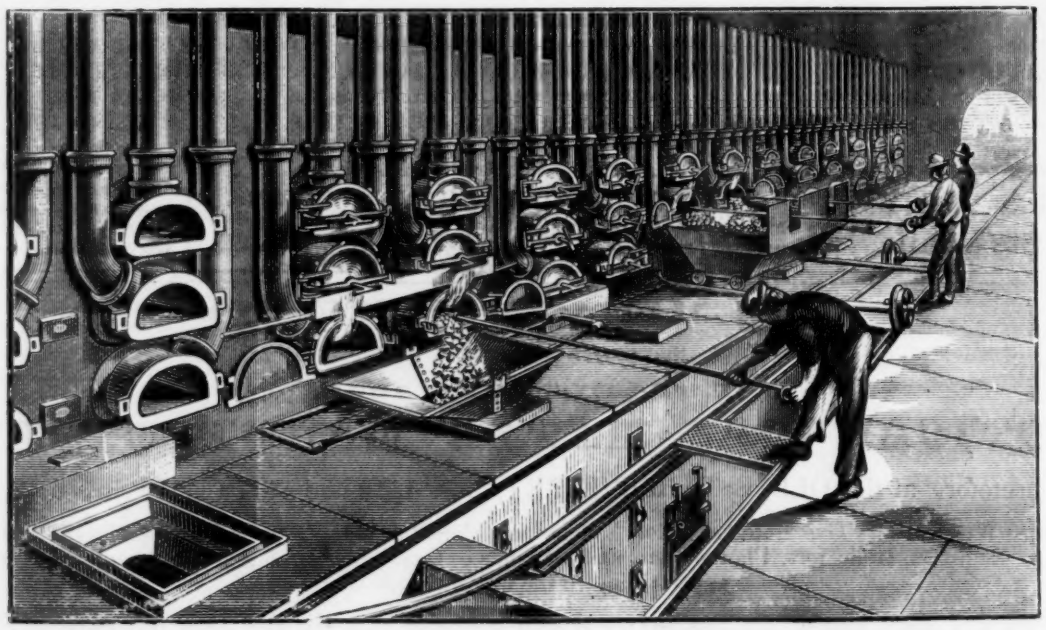

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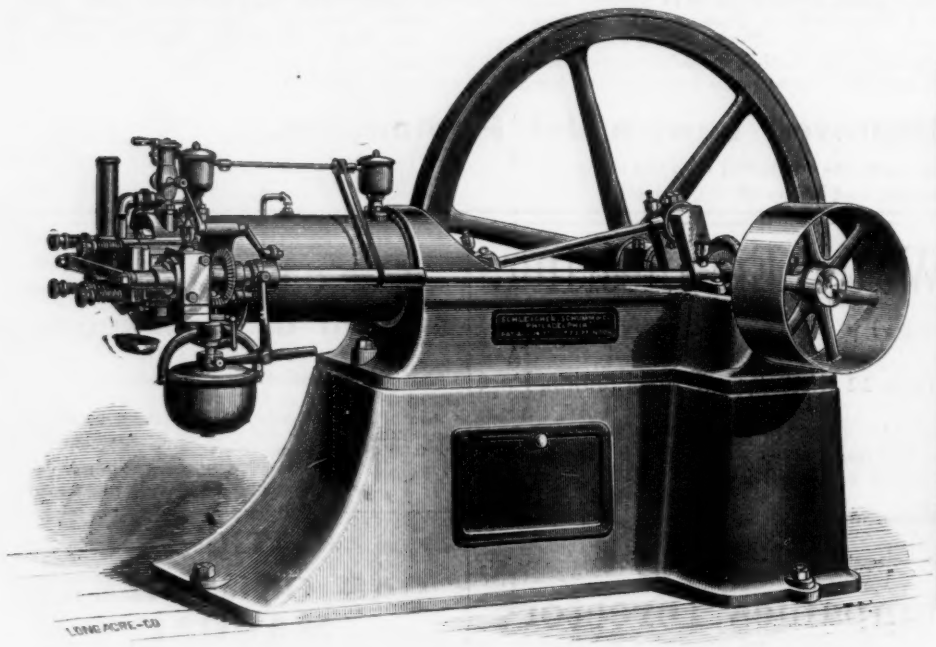

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